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THE AV-8B DECISION

by

Joel L. Goza

June 1982

Thesis Advisor:

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REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
	AN 9 765	
4. TITLE (and Subtitle)	5. TYPE OF REPORT & PERIOD COVERED	
THE AV-8B DECISION	Master's thesis; June 1982	
	6. PERFORMING ORG. REPORT NUMBER	
7. AUTHOR(s)	8. CONTRACT OR GRANT NUMBER(s)	
Joel L. Goza		
9. PERFORMING ORGANIZATION NAME AND ADDRESS	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS	
Naval Postgraduate School Monterey, California 93940		
11. CONTROLLING OFFICE NAME AND ADDRESS	12. REPORT DATE	
Naval Postgraduate School Monterey, California	June 1982	
	13. NUMBER OF PAGES	
	95	
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)	15. SECURITY CLASS. (of this report)	
	Unclassified	
	16. DECLASSIFICATION/DOWNGRADING SCHEDULE	
17. DISTRIBUTION STATEMENT (of this Report)		
Approved for public release; distribution unlimited.		
18. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
19. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
AV-8B Harrier Advanced Harrier AV-8B Advanced Harrier Controversy		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number)		
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The AV-8B Decision

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Submitted in partial fulfillment of the
requirements for the degree of

MASTER OF SCIENCE IN MANAGEMENT
from the
NAVAL POSTGRADUATE SCHOOL
June 1982

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ABSTRACT

This thesis is a case study of the debate over the decision of the United States Government to procure the McDonnell Douglas AV-8B Advanced Harrier V/STOL jet aircraft for the U. S. Marine Corps. It includes a history of the development of the AV-8A Harrier, the development of the Marine Corps' concept of employment of V/STOL aircraft, and the development of the AV-8B. The study centers around the actions taken by the Office of the Secretary of Defense, the Department of the Navy, the U.S. Navy, the U.S. Marine Corps, and the Congress of the United States in the controversy over the AV-8B during the period 1977-1980. That controversy was over the decision to equip the Marine light attack force during the 1980's with either the AV-8B Advanced Harrier or the A-18 Hornet to replace worn-out A-4M Skyhawks and AV-8A Harriers. The thesis follows both sides of the argument over the AV-8B in the context of the PPBS process, the President's budget process, and the Major System Acquisition process.

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I. INTRODUCTION

This thesis is a case study of the organizations and people involved in the decision to acquire the AV-8B Advanced Harrier jet aircraft for the United States Marine Corps. The acquisition of this particular aircraft was unusual because of the large controversy it created. This thesis will answer the question: What organizations were involved, who were the actors involved, and what were their actions throughout the controversy over the decision to acquire the AV-8B?

The method of research for this thesis was to search for and read the available literature on the development, procurement, and employment of the Harrier aircraft, and the controversy over its development and procurement. The sources of data for this thesis were: military and aeronautical journals (both foreign and American), periodical literature, technical reports, General Accounting Office Reports, and Congressional Hearings and Reports. All of the sources used for this thesis were unclassified.

The thesis includes the history of the Harrier aircraft, and how it came in to use in the U.S. Marine Corps (see Appendix A for a concise chronology). The concept of operational employment of the original Harriers by the Marine Corps is covered, as well as the results of Marine operational experience with that first generation Vertical and Short Take-Off and Landing (V/STOL) aircraft. The thesis centers around the development of an American-made second generation Harrier and the controversy over that Advanced Harrier, as well as the other aircraft that was competing for a place in the Marine Air Wings, the F/A-18 Hornet.

This thesis studies the story of the acquisition of the AV-8B in the context of the bureaucratic procedures for acquiring a major weapon system. Funding for Marine aircraft is included in the Navy budget because all Marine Corps airplanes are purchased with money that is appropriated by Congress in the Aircraft Procurement Navy (APN) appropriation. The Aircraft Procurement Navy appropriation is just one part of the defense budget that must work its way through the Department of Defense Planning, Programming, Budgeting System (PPBS) into the President's proposed budget that goes to Congress each January. In addition to being included in the military long range financial plan (the FYDP or Five Year Defense Plan) and in the annual budget (in the APN appropriation), a new aircraft program must pass all the hurdles of the Major System Acquisition process. This process requires that any critical weapon system, one that requires special management and expenditure of a relatively large amount of resources, have its justification, objectives, basic concept, development, production, and acquisition periodically reviewed by military and civilian officials of the individual service involved (the Department of the Navy Systems Acquisition Review Council and the Secretary of the Navy in the case of Marine Corps aviation assets) as well as by military and civilian officials in the Department of Defense (the Defense Systems Acquisition Review Council, or DSARC, and the Secretary of Defense). This thesis will look at the people and organizations that were involved in these parallel processes for the procurement of the AV-8B Advanced Harrier.

II. THE V/STOL CONCEPT AND THE AV-8A HARRIER

A. WHY V/STOL?

In the late 1950's and early 1960's there were many American Vertical/Short Take-Off and Landing (V/STOL) aircraft designs that had been brought to the point of actually having an aircraft flying, but none of these were developed further into a fully operational aircraft [Ref. 1: p. 41]. The availability of new technology often provided a push for some new military weapon to be developed using that technology, but tight defense budgets constrained the development of many potential weapon systems. With the combination of severely constrained military spending and many new technologies being offered as possible weapons, a new idea had to show that it could satisfy a firm and proven military requirement before any money would be appropriated for development. This fact had a nullifying effect on the new concept of jet V/STOL during the 50's and 60's. By the early 1970's there was only one operational V/STOL aircraft in the world, and it was of British design and manufacture. That British program benefitted from some financial support from the United States [Ref. 2: p. 336], but there was no U.S. program in progress that was going to provide an American jet V/STOL in the foreseeable future.

By the end of the 1960's, the defense staffs of nations around the world were becoming more convinced that V/STOL tactical aircraft technology was important. Earlier events in the Middle East had shown that certain factors in the use of tactical air power were becoming more important, factors such as: independence from paved airfields, dispersal of aircraft on the ground, and greater flexibility in

operations. In Europe, defense planners began to realize that being forced to operate from a fixed number of easily targeted airfields was going to be a handicap in any future war fought there [Ref. 3: pp. 71-72]. From this realization came the requirement to develop a jet V/STOL aircraft that could provide immediate low level, high speed support in the attack, or armed reconnaissance, and perform both of these missions while operating from any suitable small clearing close to the forward edge of the battle area. The Hawker Siddeley Aircraft Company of Great Britain designed their V/STOL jet to fill that requirement.

B. THE HAWKER SIDDELEY HARRIER

The cancellation of its design for a new fighter for the Royal Air Force in 1958 made excess production capacity available at Hawker Siddeley [Ref. 2: p. 336]. To make use of that excess capacity, work was begun on a jet V/STOL airplane. A suitable engine, called the BE53, was already under development by the Bristol Aero Engine Company (who later merged with the Rolls Royce Engine Company). 75% of the funds for the BE53 were provided by the United States through the Mutual Weapons Defense Program (MWDP) [Ref. 4: p. 273]. MWDP was an American program established in Europe for the purpose of giving financial support in developing weapons of interest to NATO. Hawker Siddeley's development aircraft, called the P.1127, first flew on 21 October 1960 [Ref. 5: p. 24]. That initial flight was a hover done while the aircraft, for safety, was still tethered to the ground. The P.1127 made its first free hovering flight the following month. The first flight during which the P.1127 transitioned from a hovering takeoff to conventional forward flight was made in September 1961 [Ref. 2: p. 336].

An agreement between the United States, the United Kingdom, and West Germany enabled Hawker Siddeley to build nine follow-on aircraft to the P.1127. These aircraft were called Kestrels. The nine Kestrels were used by a tripartite squadron during 1965 and 1966 to evaluate the operational potential of jet V/STOL [Ref. 5: p. 24]. The three major services of the United States, the U.S. Air Force, the U.S. Army, and the U.S. Navy, all sent pilots to participate in the evaluation. The conclusion of the squadron's evaluation was that the Kestrel did have significant operational potential. After the Kestrel evaluation, the U.S. and Germany lost interest in the aircraft, and Britain continued the program alone.

In 1967, the Hawker Siddeley facility at Kingston-upon-Thames received their first order for the world's first operational jet V/STOL aircraft, which was now named the Harrier [Ref. 6: p. 569]. The Royal Air Force ordered 77 of the single seat Mk1's and 13 of the two-seated Mk2 trainers. By April of 1969 the first Harrier squadron was in service with the RAF.

C. A CLOSER LOOK AT THE HARRIER

The Harrier is a single-engine, transonic, turbofan aircraft. Fan and turbine air is exhausted through four rotatable nozzles instead of going out through a tailpipe as in Convention Take-Off and Landing (CTOL) aircraft. This type of V/STOL design is called the vectored, or deflected, thrust design [Ref. 7: p. 34]. The Harrier type of V/STOL design is also known as the lift/cruise design. For vertical flight the engine thrust is deflected, or vectored, vertically downward and for forward flight the engine thrust is vectored to the rear. For braking in flight the nozzles, or ducts, can be vectored 18 degrees forward of the vertical,

and for other maneuvers the nozzles can be set to any position in between. Control of the aircraft's attitude while hovering is accomplished through a reaction control system which operates on engine bleed air through the wing-tips, the nose, and the tail. The Harrier has the combat thrust-to-weight ratio of a conventional fighter using full afterburner, but it uses much less fuel because it has no afterburner. See Appendix B for more detailed specifications of the Harrier.

The only other vertical design in operation today is the Vertical Take-Off and Landing (VTOL) lift-plus-lift/cruise design found in the Soviet YAK-36 Forger [Ref. 8: p. 27]. A West German aircraft, the VAK-191, also employs this design, but it is only in the prototype stage. In this design there is a large engine with one swivelling exhaust in the rear of the aircraft combined with one or more smaller lift-only engines forward [Ref. 1: p. 35].

D. THE U.S. MARINE CORPS TAKES ON THE HARRIER

The philosophy of close air support in the Marine Corps has not changed since the 1920's when it was first used. Close air support is air attacks against hostile targets close to friendly forces which require detailed integration of each air mission with the fire and maneuver of these forces [Ref. 9: p. 68]. Exactly how this close air support of maneuvering ground combat units is accomplished has changed throughout the years as weapons and types of aircraft have changed, but the basic philosophy has not. Close air support in the Marine Corps is consumer oriented [Ref. 10: p. 115]. This means that in the Marine Corps the ground commander is not told what type of air support he is going to get and when he is going to get it, but he orders the air support he needs to complement his scheme of

maneuver as he formulates his plan of attack. The whole purpose of having a unique Marine air force is to support the ground commander with aviation assets that have been integrated into, and are a permanent part of, the Marine air-ground team.

Hand-in-hand with the Marine's philosophy of close air support is their commitment to the V/STOL concept:

This commitment was formally stated in 1957 when the Commandant of the Marine Corps, General Randolph HCC. Pate, stated in a letter to the Chief of Naval Operations, "Vertical take-off and landing characteristics are an ultimate requirement for all Marine aircraft in support of amphibious operations in the future... Obtaining a STOL/VSTOL capability is vital to Marine Aviation." In 1963, when technology advancements made it appear possible that V/STOL aircraft could be competitive with conventional aircraft, the Marine Mid-Range Objective Plan stated: "V/STOL capability will be included in the requirement for any aircraft if it provides a worthwhile improvement in operational effectiveness without unacceptably degrading flight performance or unduly increasing overall support and maintenance." The advantages of V/STOL were again recognized in a 1965 study of long-range options. The recommendations of this study led to the formal requirement for the AV-8A Harrier aircraft in 1965. [Ref. 11: p. 58]

For the Marine Corps, the key to close air support is responsiveness. After a series of studies dating back to the 1950's, the Marine Corps developed a concept involving the use of aircraft capable of vertical flight that could stay on the ground close to the battlefield. In 1968, an operational production V/STOL aircraft, the Harrier, became available and the Marine Corps was watching its development very closely [Ref. 12: p. 25]. The Marine Corps had not participated in the tripartite evaluation of the Kestrel, but they were very interested in the new Harrier with its ability to operate from small clearings close the forward edge of the battle area, its ability to operate from helicopter-sized platforms on ships, and its ability to operate in both of these environments without any modifications to the aircraft. These capabilities seemed very complementary

to the Marine's requirement for responsiveness in close air support and to the Marine's unique mission of amphibious warfare. In early 1969 the Marine Corps sent two officers, Colonel Tom Miller and Lieutenant Colonel Bud Baker to England to fly the Harrier [Ref. 5: p. 24]. Speaking of some of the Harrier's unique capabilities that he had investigated during his flight evaluation in England, Col. Miller said, "...these advantages provide an unprecedented potential which could lead to a complete overhaul in aircraft tactics and procedures." [Ref. 5: p. 27] The Marine Corps was convinced that the Harrier was an aircraft suitable for their use. In March of 1969 the Marine Corps ordered 12 Mk50 Harriers [Ref. 6: p. 569]. The Mk50 was Hawker Siddeley's export version of the Harrier that used a slightly more powerful engine, called the the Pegasus 11, to meet Marine Corps specifications.

In April 1971 Marine Fighter-Attack Squadron 513 (VMFA-513), then equipped with McDonnell Douglas F-4 Phantoms, was redesignated Marine Attack Squadron 513 (VMA-513) and received the first six U.S. Marine Harriers, which had been given the American designation: AV-8A [Ref. 13: p. 1].

E. THE MARINE CORPS EMPLOYMENT OF V/STOL

Between 1969 and 1971 the Marine Corps prepared for their coming experiment with the Harrier. There was considerable cooperation on the part of the British in this endeavor, particularly by the Royal Air Force [Ref. 13: p. 2]. The Marines got a good head start on their own training program by having four instructor pilots train with the RAF. The willingness of the RAF to sacrifice valuable Harrier flight time in order to train those Marine pilots in RAF test and operational billets gave a tremendous boost to the

Marine program. Along with the pilots, a significant number of Marine maintenance personnel were trained by Hawker Siddeley and the RAF in England.

In addition to the preparation of personnel to man the first Marine Harrier squadron, the Marine Corps needed to develop a doctrine of exactly how Marine squadrons were going to operate with this new type of aircraft. During 1970 the Marine Corps Development Center in Quantico, Virginia refined the old concept of stationing a V/STOL capable aircraft on the ground close to the supported units into a detailed basic doctrine that could be tested by the first squadron. The Marines planned to use the Harrier as a specialized aircraft with the primary mission of responding to on-call requests for close air support [Ref. 14: p. 1]. The manner in which the Harrier would be used for an on-call mission is very different from the way a CTOL aircraft would be used.

When a ground commander plans for close air support to be used in his plan of attack, that support is called preplanned. Preplanned close air support is either scheduled or on-call. Scheduled close air support is that which will be delivered on specified targets at a specified time. On-call close air support is that in which the commander knows which target he wants attacked, but he does not know exactly when the support will be required, so he requests that mission be available any time he calls for it. With conventional aircraft there are three techniques for providing on-call close air support:

1. Aircraft can be diverted from a lower priority mission. Aircraft that are already airborne in the vicinity of the on-call mission can be used for the on-call mission instead of for the mission for which they were intended.

2. Aircraft can be put on strip alert. In this technique, aircraft are specifically assigned to the on-call mission. These strip alert aircraft are fueled and pre-armed with appropriate weapons and the pilots are standing by, waiting to "scramble" to their planes when a request for close air support is received.
3. Aircraft can be flown in an orbiting pattern, in a location safe from anti-aircraft fire, near the area from which calls are to be expected. In this technique, the required number of aircraft are armed with the proper ordnance and kept airborne, circling near the unit they are assigned to support. Just before the fuel in these aircraft is down to the amount of fuel needed to do the mission and still be able to return to the airfield, freshly fueled aircraft arrive to take their place.

There are several disadvantages to handling on-call requests with these techniques. Aircraft that are diverted from another mission will most likely be loaded with a type of ordnance that is not the best for the on-call mission. If the airfield where the strip alert aircraft are located is not close to the area where the support is required, then such precious time is used up in getting to the target area. Orbiting aircraft are very responsive, but that technique is very expensive in fuel and in the amount of assets needed to keep the right number of aircraft airborne and in orbit continuously.

The Marine Corps developed their concept of employment of the Harrier to take advantage of two important attributes of V/STOL aircraft: the ability to displace rapidly and the ability to operate from dispersed sites. By relying on these two important Harrier features, the concept developed by the Marines combines the best qualities of the strip alert and

the orbiting techniques - responsiveness and efficiency. This is accomplished by substituting "ground" loiter near the supported troops for "air" loiter by orbiting aircraft [Ref. 15: p. 24]. By dispersing the Harriers and positioning them close to the maneuver elements they are to support, a much higher sortie rate* can be achieved. This means increased responsiveness to the ground commander's calls. Of course, the Marines had to develop this concept so that it fit in with their amphibious mission. In addition, they had some other requirements for the new concept to meet. First, the concept had to work without any major changes in the existing Marine Tactical Air Control System. Second, the concept had to be supportable without a large additional logistics burden.

The fundamental idea behind the concept is the Harrier's flexibility. The concept works by using the Harrier's ability to operate from many different types of bases. The types of bases used in the concept are [Ref. 14: p. 2]:

1. Sea Base. This would be the means of getting the Harriers to the Amphibious Objective Area (AOA), and could be any of several kinds of ships, such as a large aircraft carrier (CV) or one of the smaller amphibious helicopter carriers (LPH or LHA). On these large ships, the squadron would be deployed with full logistic support (primarily fuel and ordnance) and full maintenance support available. A study was conducted at the Naval War College Center for Advanced Research which concluded that it was feasible to use several types of merchant ships as platforms for V/STOL aircraft operations [Ref. 16: p. 68]. The

* A sortie is one operational flight by one aircraft [Ref. 9: p. 316]. A sortie rate is the number of sorties flown by an aircraft during a specified time period, usually one day.

study emphasized that this idea was feasible without depending on any dramatic technological breakthrough and would utilize hardware (commercial freight containers and Marine Corps expeditionary shelters) already in existence.

2. Sea Platform. This would be any ship that had a helicopter-sized platform that the Harrier could temporarily land on, then takeoff from when called, such as an LPD or an LST. There would be no ordnance support, no maintenance support, and very limited fuel support.
3. Forward Site. This would be an austere site ashore where the Harrier would land temporarily, like the sea platform, to wait for a mission call. A forward site could be a clearing in the woods, a road, or a small stretch of hard-packed beach. There would be no logistic or maintenance support available at one of these sites.
4. Facility. This would be an ashore airfield of very small size to accommodate Harriers and helicopters, with perhaps a 1000 foot strip of aluminum matting for a short runway. If the Harrier can get a short run for takeoff instead of a strictly vertical takeoff, it can carry a much larger payload. At a facility, some limited maintenance and some common types of ordnance would be available.
5. Main Base. The main base would be like the sea base, only ashore. At this base the full range of logistic and maintenance support would be available.

While the amphibious task force transits to the amphibious objective area, the Harrier squadron would be deployed on a sea base. As the task force approached the AOA the Harriers would arm and disperse to sea platforms throughout the task force. The purpose of this dispersal would be

protection from air attack and also to enable the Harriers to be more responsive when used over a wider area. After flying a mission, the Harrier would return to the sea base to be refueled and rearmed, then again disperse to some sea platform to await a call to action. When more responsiveness was needed, and the friendly forces had secured enough terrain, the Harriers could begin to operate ashore. The operations ashore would increase in three phases [Ref. 15: pp. 21-22].

Phase I. Small detachments would operate from forward sites after refueling and rearming at the sea base. If there was not a suitable natural area for the forward site, then a 75-foot square mat could be put down, or a plastic mat could be sprayed onto a clear area in a few minutes. After flying a mission from the forward site, the aircraft would return to the sea base for fuel, bombs, and any needed maintenance before returning to a forward site to land and wait for a call. In this phase, aircraft would be operating ashore close to the supported units much earlier than any conventional aircraft could.

Phase II. Operations would begin from facilities. These would be expanded sites with a strip (laid down or possibly using a section of road) and with fuel, ordnance, and limited maintenance capability. Use of forward sites during Phase I would certainly increase responsiveness, but in the establishment of a facility there is a new capability for the amphibious task force that is derived from V/STOL characteristics. Responsive, survivable fixed-wing close air support would be available while the buildup of large complex bases is avoided. This is a significant increase in the capabilities and flexibility of the amphibious task force.

Phase III. If the amphibious operation is of long duration, then a carrier task force will not be able to support Harrier sea bases on a continuing basis, because it may be needed for other missions away from the amphibious objective area. During this phase main bases are established ashore. During continuing operations, Harriers would operate from the most complete and efficient base available, but more facilities and forward sites would be established as needed for responsiveness when the situation dictated, to insure the ground commander the necessary close air support he requires.

P. THE MARINE CORPS' HARRIER EXPERIMENT

By 1972 the Marine Corps had 12 Harriers in operation with VHA-513. Additionally, there were 48 more Harriers on order from Hawker Siddeley, to be paid with FY71 and FY72 funds [Ref. 17: p. 52]. However, there were some members of Congress who felt that the V/STOL technique was premature and too expensive [Ref. 18: pp. 39-40]. Specifically, there were three members of the Senate Armed Services Committee closely associated with the Air Force* who wanted the A-X aircraft (which later became the A-10) for the Marine Corps, at the expense of the AV-8A. The Marine Corps thought that the Harrier didn't belong in the A-X controversy over what aircraft was best to support the Army and that the Harrier was best for use in amphibious operations. The Marine Corps needed to get their V/STOL concept working and show that the AV-8A was really what they needed.

* Senators Goldwater and Cannon, who were Major Generals in the Air Force Reserve, and Senator Symington, who was a former Secretary of the Air Force.

In 1972 the Marine Corps conducted an operation to validate their concept of employment for the Harrier. This operation was called VERSATILE WARRIOR [Ref. 17: pp. 52-53]. Exercise VERSATILE WARRIOR was conducted at Camp Lejeune, North Carolina by a six plane detachment from VMA-513 and was analyzed and reported on by the Weapons System Evaluation Group. The WSEG, as it was known, was an organization within the Department of Defense under the cognizance of the Under Secretary of Defense for Research and Engineering (USDR&E). The WSEG was an objective group of evaluators from outside the Department of the Navy, headed by an Air Force Major General, whose purpose was to evaluate Navy systems [Ref. 19]. The WSEG was specifically assigned as the test directorate for the Harrier. For this exercise, the Marine Corps anticipated a regular sortie rate of four per aircraft per day and a surge rate (an all out effort to get the maximum rate for a short period of time) of six per aircraft per day. The actual rates achieved were 6.4 regular, and 10.2 for a 16 hour surge period, which greatly exceeded the anticipated rates. The Harrier's performance in the VERSATILE WARRIOR exercise earned a very glowing report from the objective Weapons System Evaluation Group and completely won over some officials who previously held strong reservations about the V/STOL aircraft. That the AV-8A came through its trials exceedingly well should not have been a surprise. The Harrier had been through ten years of development and had 12,000 hours in operation with two Royal Air Force squadrons based in Germany. It was truly an "off the shelf" aircraft, something that the U.S. military was not used to having [Ref. 20: p. 1036].

By 1973 the Marine Corps felt that its experience with the Harrier and the results of exercises like VERSATILE WARRIOR had certainly validated the operational concept they

had conceived. The Marine Corps now had plans to convert their air arm into an all V/STOL force. This conversion would be accomplished in three phases [Ref. 21: pp. 48-51].

Phase I. Procure the AV-8A and demonstrate that the V/STOL concept is valid. The Marines operated the Harriers in almost every conceivable environment, and though they had some problems the operations were considered very successful. The AV-8A was a first generation aircraft, and admittedly had some shortcomings, such as limited range and payload. Even so, the Marine Corps considered that they had proved the concept valid. They then began to develop further doctrine, command and control procedures, and support measures to insure that new generations of V/STOL aircraft would be able make optimum use of their unique capabilities.

Phase II. In May of 1973 the Commandant of the Marine Corps signed a Specific Operational Requirement (SOR) for an advanced V/STOL aircraft. The objective of this SOR was procurement of a light attack V/STOL aircraft with improved range and payload characteristics to replace all of the Marine Corps' light attack planes, AV-8A's and the A-4 Skyhawks, presently in the inventory. There would be several benefits to this plan. The overall responsiveness of the support to the ground commander would be greatly enhanced, the number of aircraft types in the inventory would be decreased, and the number of aircraft requiring the SATS expeditionary airfield* would be decreased.

Phase III. This phase is the very long range part of the plan. During this phase a V/STOL fighter aircraft would be developed and procured. When that is accomplished,

* SATS is the Short Airfield for Tactical Support. This is a small expeditionary airport used by the Marines that can be carried on amphibious shipping or transported by air. It has a portable aluminum runway with arresting gear like an aircraft carrier.

the conversion of the Marine air wings to V/STOL aircraft exclusively will be complete.

The advanced V/STOL aircraft that the Marine Corps wanted in phase II of their plan was the AV-16A [Ref. 21: p. 49]. The AV-16A was to be an improved Harrier with a new and more powerful engine. The new engine was to be an advanced version of the Pegasus 11 used in the AV-8A, to be called the Pegasus 15. The AV-16A ran into some problems. The Pegasus 15 was to be developed jointly by Britain and the U.S., but the British said they could not afford to take part in the development and pulled out of the program. The Marines could not get funds to carry on the program by themselves, and the AV-16A project was cancelled [Ref. 22: p. 749]. In spite of the AV-16A setback, the Marine Corps was still convinced that the V/STOL concept was sound and that the Harrier was the current answer to providing the most responsive close air support.

In addition to the Marine Corps' need, there were other pressures for the further development of operational V/STOL capabilities. With changing national commitments, the requirement for rapid entry into an isolated area and rapid withdrawal after the mission is complete does not permit the insertion and withdrawal of conventional fixed wing aviation quickly enough to provide the continuous and responsive air support needed by the maneuver elements [Ref. 21: p. 48]. Also, international political influences are forcing new assessments of strategies and a search for weapons to carry those strategies. As a result of these assessments, the U.S. Navy has been spurred to look for new concepts for war at sea and modernization of its weapons systems, including the use of V/STOL jet aircraft. In Europe, the new technology that was developing in the area of runway denial was putting new emphasis on further development of jet V/STOL in

order to avoid dependence on runways. There were efforts to develop a bomb that would cause large areas of concrete to heave and shatter rather than cause a crater, or a cluster-type weapons that would scatter thousands of delayed-action bomblets along runways [Ref. 4: p. 276]. Runway denial operations such as these would shut down CTOL aircraft operations, but would have much less effect on V/STOL operations.

With all this pressure, the Marine Corps asked itself if there was any way to get the advanced V/STOL they wanted without having to depend on the development of a new engine, which they couldn't afford at the time. The answer to that question was the AV-8B Advanced Harrier.

III. THE AV-8B ADVANCED HARRIER

A. THE MCDONNELL DOUGLAS HARRIER

The Marine Corps was still acquiring AV-8A's when they started planning for a growth version of the Harrier with improved performance over the AV-8A. This second generation Harrier was given the designation of AV-16A. The AV-16A would achieve its improved performance over the AV-8A by using a more powerful engine, called the Pegasus 15. Two American companies, McDonnell Douglas and Pratt & Whitney, had a plan to develop that Harrier successor [Ref. 23: p. 58].

Earlier, when the Marine Corps decided to buy up to one hundred more Harriers beyond the original twelve purchased from Hawker Siddeley, McDonnell Douglas had tried to get a license to produce the AV-8A's in the United States [Ref. 20: p. 1036]. They were unsuccessful in that attempt. Congress determined that it would be uneconomical to set up production in the United States for that small number of aircraft (100), especially when the engines would be manufactured by Rolls Royce in England in any case. Based on that analysis Congress disapproved McDonnell Douglas' request. Thus the Marines bought all their AV-8A's from Hawker Siddeley, which became a part of the nationalized aircraft industry called British Aerospace. In 1972, McDonnell Douglas and Pratt & Whitney intended to team with Hawker Siddeley and Rolls Royce to design and produce the AV-16A. The main features of the improved model, in addition to the higher performance engine, were a new aerodynamically improved wing and better takeoff performance. In 1973 the U.S. Marine Corps submitted the Specific Operational

Requirement for an advanced V/STOL light attack aircraft with increased payload and range capability. The AV-16A was the airplane the Marines had in mind [Ref. 24: p. 33].

Almost from the beginning it seemed unlikely that the AV-16A would be approved. Because a brand new engine would power it, the development program for the AV-16A would have been complex and very expensive for the modest improvements it would have brought. The project got off to a slow start because the British government was having severe financial difficulties during that time period. For two years Hawker Siddeley and McDonnell Douglas worked together on the AV-16A concept. During those two years The United States tried to get the United Kingdom to enter a formal cooperation agreement on the project [Ref. 23: p. 59]. According to the terms of the proposed agreement, the United Kingdom would contribute funds and share in development work, acting as an equal partner with the United States, sharing equally the risk and the profit. In June of 1974 the British Ministry of Defence finally rejected the United States' cost sharing offer. However, Great Britain still wanted an improved Harrier. In May of 1975 the Minister of Defence announced the decision of the British to go with the development of another aircraft. The British were going for a low-risk derivative of the standard Royal Air Force Harrier to be called the Sea Harrier [Ref. 25: p. 1175]. A detailed cost analysis showed that the development and production of the Pegasus 15 engine solely in America would cost more than the United States was willing to afford. The research and development costs of the AV-16A were estimated at \$900 million, half of which would have been for the Pegasus 15 engine [Ref. 26: pp. 4789-4790]. After a joint Navy-Marine Chief of Naval Operations Executive Board (CEB) met to decide the AV-16A question in 1975, the AV-16A project was terminated [Ref. 26: p. 4790].

In July of 1975 McDonnell Douglas announced that it would develop an improved Harrier called the AV-8+ (AV-8 Plus) [Ref. 23: p. 57]. As advertised by McDonnell Douglas, the AV-8+ would have the range, payload, and weapons carrying capability to perform the mission of McDonnell Douglas' own A-4 Skyhawk, a light attack aircraft now in service with the Marine Corps. Because the development of a new engine was cost prohibitive, the AV-8+ improvements had to be achieved aerodynamically. The decision was made to incorporate the major aerodynamic features of the AV-16A into an aircraft powered by the Pegasus 11 engine currently used in the AV-8A. The designation AV-8+ was eventually dropped and the McDonnell Douglas Advanced Harrier was designated the AV-8B.

At the beginning of 1975 there didn't seem to be much future for an advanced follow-on to the AV-8A, but by the end of that year there was growing support for the AV-8B. Over the next six years McDonnell Douglas worked with the Marine Corps on the design of the AV-8B, and prototypes were built and tested. During that period the United States was still trying to get the United Kingdom to share in the Advanced Harrier program. Finally, In July of 1981, the United States and Great Britian completed negotiations to establish a cooperative program for sharing in the development and production of at least sixty McDonnell Douglas AV-8B's for the Royal Air Force. That agreement also provided for British Aerospace participation in a Marine Corps purchase of about 336 of the Advanced Harriers. The negotiations concluded with a Memorandum of Understanding (MOU) between the two governments [Ref. 27: p. 63]. The MOU calls the airframe work to be split 60% for McDonnell Douglas and 40% for British Aerospace, and the engine work to be split 75% for Rolls Royce and 25% for Pratt & Whitney. The costs

for research and development will be split 50-50. McDonnell Douglas and British Aerospace will also collaborate in world-wide marketing of the AV-8B when it becomes available for export about 1985. Because the AV-8B is a McDonnell Douglas design, the market share of any third country sales will be 25% for British Aerospace and 75% for McDonnell Douglas.

B. THE AV-8B IMPROVEMENTS

In order to make the improvements on the AV-8B substantial enough to justify the expense of producing it, McDonnell Douglas set out to apply as much state-of-the-art technology as possible to the Advanced Harrier [Ref. 28: p. 1]. The improvements on the AV-8B fall into four main categories:

1. Aerodynamic
2. Propulsion
3. Composite Structure
4. Avionics Technology

The biggest aerodynamic improvement is the new wing designed for the AV-8B. The new wing design incorporates a supercritical airfoil developed by McDonnell Douglas. The technology of the supercritical wing, designed to reduce drag and increase the aerodynamic efficiency, was developed for the AV-16A and tested extensively in the NASA/Ames transonic wind tunnel. The new wing is larger and has a higher aspect ratio than the old wing. The new wing makes extensive use of composite materials instead of being made completely of metal. Use of the new composite material technology means that more than 23% of the AV-8B airframe, including some parts of the skin of the wing and fuselage and some of the internal structure of the wing, are made of graphite epoxy in addition to aluminum and titanium. The

benefits of composite materials are that they have no known fatigue life, they do not corrode, they are easier to repair, and they are much lighter than aluminum [Ref. 29: p. 70]. The use of composite material saves over 300 pounds in the overall weight of the airplane. Weight saving is important in order to get AV-16A performance from an aircraft with an AV-8A engine. There are several additional benefits to having a larger and thicker wing on the AV-8B besides more aerodynamic efficiency. One of these advantages is that the internal fuel tanks can be larger. The AV-8B can carry 2,000 pounds more fuel than the AV-8A. The larger and stronger wing also enables the AV-8B to have seven pylons for carrying external stores (bombs, missiles, external fuel tanks, etc.) compared to five on the AV-8A. The new wing also gives the AV-8B a wider VIFF envelope [Ref. 29: p. 74]. VIFF stands for Vectoring In Forward Flight, and refers to the technique pioneered by the U.S. Marine Corps of swivelling the thrust nozzles of the Harrier while the aircraft is in forward flight. Use of this technique can give the Harrier a maneuvering advantage over conventional aircraft. The AV-8A has the capability to use VIFF, but lacks the structural strength to exploit the potential fully, which the AV-8B will be able to do.

Several aerodynamic changes enable the AV-8B to improve lift performance. The air intakes of the aircraft were altered to make the air capture and throat areas larger to give better air flow at low speeds and high power settings. These alterations, plus some changes that allowed the turbine entry temperature to be raised, and some modifications to the exhaust nozzle design, increased the thrust of the Pegasus 11 engine by about 1,000 pounds. Another significant change is the addition of Lift Improvement Devices (LID's) [Ref. 28: p. 4]. The LID's are made up of a

retractable "cross-dam" or fence that comes down across the bottom of the fuselage, and two strakes, or long panels, attached along the bottom of the fuselage. Together, the fence and the strakes form a box with an open bottom. The box formed by the LID's counters a "suck-down" effect that occurs in the AV-8A when the engine exhaust strikes the ground, reverses direction and flows up around the fuselage at high velocity. The high velocity air flow causes a low pressure that tends to pull the aircraft down. The LID's capture the reflected jet flow and convert some of that high velocity flow into pressure that increases lift force.

Avionics changes in the Advanced Harrier include the addition of radar warning equipment, secure voice equipment, and defensive electronic countermeasures equipment [Ref. 24: p. 74]. The AV-8B also has the Angle Rate Bombing System (ARBS), now used on the latest version of the A-4 Skyhawk, as part of an armament system that has been optimized for the close air support mission. The ARBS allows the delivery of ordnance with a much higher degree of accuracy than previous systems. The flexibility and accuracy of the ARBS combines with the stores management system to provide a high single pass kill probability along with low pilot workload [Ref. 28: p. 10]. The AV-8B also incorporates advanced control and display techniques, similar to those designed for the F-18, to decrease the pilot workload [Ref. 30: p. 63]. One technique, called Hands On Throttle And Stick (HOTAS), allows the pilot to perform many cockpit chores without removing his hands from the primary controls. Another technique is an improved Heads Up Display (HUD), which allows the pilot to read his flight instruments and weapons aiming/status displays without looking down into the cockpit. Another change was the addition of a Stability Augmentation and Attitude Hold System (SAAHS), which gives the pilot

steadier and more positive control of the aircraft with less effort.

All of these improvements tested out well in the wind tunnel, but could they be demonstrated on a flying airplane? The AV-8B concept would have to be proven in flight before any funds could be allocated for production.

C. TESTING OF THE AV-8B CONCEPT

In March of 1976 the Defense Systems Review Council (DSARC) recommended that the AV-8B program begin by having McDonnell Douglas build two prototype Advanced Harriers [Ref. 29: p. 75]. The prototype Advanced Harriers were called YAV-8B's. The purpose of the prototype program was to advance V/STOL technology and to verify the AV-8B design concept prior to its next DSARC review in mid-1979. The DSARC would decide at that time if the AV-8B would go into full production. The flight demonstration phase of the YAV-8B program was a thirty-three month effort lasting from November 1976 until July 1979. The YAV-8B's were two converted AV-8A's, fitted with the AV-8B wing and a few of the other improvements. The YAV-8B's successfully demonstrated the predicted performance and flying qualities of the improvements incorporated in them [Ref. 31: pp. 49-50]. All of the required performance standards were either met or exceeded.

During the late 1970's, as the Marines made their plans for converting their light attack force to all V/STOL by phasing in AV-8B's, a gap in Harrier service was discovered. The original AV-8A's then in service with the Marine Corps were physically not going to last until they could all be replaced by Advanced Harriers. Unless some corrective action was taken, there would be a period during which the Marine Air Wings would not have any Harriers in service.

Because the YAV-8B improvements were so successful, plans were made to extend the lives of the original AV-8A's through a Conversion In Lieu Of Procurement (CILOP) program. In this program, modifications similar to those of the YAV-8B's will be made on the AV-8A's and they will be redesignated AV-8C's. The AV-8C's will be transferred to the Reserve Marine Air Wing as they are replaced by AV-8B's. [Ref. 32: p. 42]

As the YAV-8B prototype program progressed successfully, the Marine Corps considered that having validated the V/STOL light attack concept with the AV-8A, the McDonnell Douglas AV-8B would now provide the operational capability required for its light attack force during the 1980's.

D. THE CONTROVERSY

In 1977 a controversy over the AV-8B program arose. The U.S. Marine Corps wanted the Advanced Harrier for their light attack force, but the program had opponents in the Department of Defense. There was a fight in the Pentagon over the AV-8B that was carried over to "the Hill." The following chapters present the views of the major participants in that fight.

IV. THE DEPARTMENT OF THE NAVY VIEW

A. THE F/A-18 HORNET

The primary reason there was a controversy over the AV-8B Advanced Harrier program was that some officials in the Department of Defense felt that another airplane under development for the Navy and the Marines, the McDonnell Douglas F/A-18 Hornet, could fill the Marine's light attack requirement better than the AV-8B. In 1974, the Navy had started to look for a new light weight multi-mission fighter aircraft, and asked aircraft companies to submit their ideas. Later that same year Congress directed the Navy to investigate versions of the General Dynamics YF-16 and Northrop YF-17 light weight fighter prototypes, then under evaluation by the U.S. Air Force, instead of starting the acquisition process from scratch on a whole new airplane [Ref. 33: p. 384]. McDonnell Douglas, with its expertise in building aircraft for the Navy, entered into an agreement with Northrop to build a McDonnell Douglas/Northrop F-18 based on the Northrop YF-17. The F/A-18 was selected by the Navy with McDonnell Douglas as the prime contractor and Northrop as the associate contractor. The F/A-18 Hornet is a conventional take-off and landing, single-seat, twin-engined, carrier based, naval strike fighter. The Hornet has both attack and fighter versions, hence its F/A designation. The A-18 attack version is identical to the F-18 fighter version except the attack version has a forward looking radar and a laser tracker for ground attack, that the fighter version does not have, and the fighter version has fuselage mounts for Sparrow air-to-air missiles that the attack version does not have [Ref. 33: p. 384]. The first Hornet flew

in September 1978, and the first production aircraft was delivered to the Navy in May 1980. See Appendix B for details of the F/A-18.

B. THE MARINE CORPS' VIEW

During the time it was trying to acquire the AV-8B, the Marine Corps was pursuing the following basic objectives for Marine aviation [Ref. 34: p. 28]:

1. Support and improve current assets to achieve the highest possible state of combat readiness.
2. Modernize and replace worn out assets with new weapon systems and create new tactics to go along with them.
3. Optimize the task organization of the Marine Corps and its weapon systems to provide the highest state of combat readiness.

The most troublesome part of trying to achieve these objectives for Marine aviation was to accomplish the second objective within the Planning, Programming, and Budgeting System (PPBS) of the Department of Defense [Ref. 34: p. 28]. The Deputy Chief of Staff for Air of the Marine Corps in 1977, when the AV-8B controversy began, was Lieutenant General Thomas H. Miller. As a Colonel, LtGen Miller had been the first Marine to fly the Harrier. Talking about the difficulty of modernizing the aircraft inventory, LtGen Miller stated:

It seems illogical to rebuild a budget annually when weapon system development and procurement takes ten to twelve years. The approval of weapon system requirements (in size and capability) seems to vary more on fiscal constraints than on the need of ground forces to meet a threat. [Ref. 34: p. 27]

Even though the modernizing task was a difficult one because of fiscal constraints, the Marine Corps felt it was in a strong position to accomplish modernization of a portion of its air assets through the AV-8B program. One of the

reasons the Marines were confident about the Advanced Harrier program was that the Marines thought they had the most efficient aviation arm within the Department of Defense [Ref. 35: pp. 50-51], and that this should entitle them to some special consideration at a time when they wanted a unique aircraft to satisfy their special needs. In the Marine's view, they had taken a small portion of the overall national military assets and formed them into an air-ground team capable of meeting almost any threat around the world. The Marine Corps was providing 15% of the nation's tactical air capabilities for only 9% of the budget. Even though the Marine Air Wings were operating approximately 28% of the Navy Department's aircraft, the Marines didn't feel that they were getting a fair share of aviation money from the Navy [Ref. 36: p. 44]. See Table I for figures on the

TABLE I

Marine Share of Navy Aircraft Procurement

FY76	FY77	FY78	FY79	FY80	FY81
8%	18%	9%	12%	16%	4%

Percentage recieved by the Marine Corps
of all dollars that buy airplanes

Marine Corps' share of aircraft dollars. Because the Marine Corps received procurement and operation money for its aviation assets through the Navy (what the Marine's call "Blue Dollars"), it was usually difficult to fund high priority Marine aviation programs that were competing against Navy priorities for scarce money resources. If a "fair share" allocation were to be used, based on a percentage of assets owned by each service, then the overall investment options

of the Navy Department would be reduced. After a "fair share" split, neither service would have sufficient funds available for commitment to major programs. The Marine Corps felt that if a "fair share" basis could not be used, then there should come a time when high priority Marine aviation programs should receive top priority within the Department of the Navy. The AV-8B program was the highest priority program in Marine aviation [Ref. 37: p. 56]. The AV-8B was the key to the long range goal of Marine aviation to convert to an all V/STOL force. The first step in that conversion was to get an all V/STOL light attack force. The Marine Corps' plan was to have its whole light attack force, consisting of A-4H's and AV-8A's, replaced with Advanced Harriers commencing in 1985. That transition would be completed by 1990, when the Marine Corps' light attack force would be made up of eight squadrons of twenty AV-8B's each. The Commandant of the Marine Corps, General Louis H. Wilson, told Congress that he would prefer to risk a fighter gap in the 1980's by not buying F-18's to replace aging F-4 Phantoms, if it would speed the Corps' switch to the all V/STOL era [Ref. 38: p. 25].

Another reason the Marine's thought they were in a strong position for procuring the Advanced Harrier was that they were thoroughly convinced that their V/STOL concept was proven, and that the AV-8B was needed to enable them to continue to employ that concept. LtGen Miller said:

I don't think anyone can question our nearly eight years of experience with the Harrier because there is no other military service, particularly in the United States that has any comparable experience. We consider our success with the Harrier a total success in providing the kind of air support we feel our young Marine on the ground needs ...
[Ref. 35: p. 53]

Yet another reason to be confident was that the Marine Corps fully expected McDonnell Douglas to demonstrate conclusively with the YAV-8B prototype program that the V/STOL

concept was here to stay [Ref. 34: p. 29]. The Marines were confident that after testing the improvements incorporated in the YAV-8B's, the results would silence the critics who said the AV-8A was not able to perform its mission because of shortcomings in range and payload capabilities. The Marine Corps recognized that the AV-8A, as a first generation aircraft, had some undesirable features such as low range and small payloads. One purpose of the AV-8B program was to correct those deficiencies as well as incorporate modern systems with better reliability and maintainability. Colonel Stanley Lewis, a program manager for the Advanced Harrier program, stated, "We're getting everything McDonnell Douglas promised in the V/STOL regime." [Ref. 31: p.50] The AV-8B was an evolutionary development based on the AV-8A operational experience, but it was not an experiment. This second generation V/STOL was expected to provide the full close air support capability required by the Marines. [Ref. 11: p. 59]

When Marine units were assigned duties with the Rapid Deployment Force (RDF), the Marine Corps felt the case for the AV-8B was strengthened [Ref. 39: pp. 1-5]. The AV-8B would have many features that would make it an excellent RDF aircraft:

1. The Harrier's basing flexibility would enable it to operate independent of any foreign airfields.
2. If it were operating from an airfield with other RDF aircraft, it would have the capability to continue to takeoff from taxiways, ramps, or even nearby roads if the runways were choked with transport aircraft during resupply missions.
3. RDF aircraft require long ferry ranges. The AV-8B could ferry from the Marine Corps Air Station (MCAS) at Cherry Point, North Carolina to Cyprus in the

Eastern Mediterranean in less than sixteen hours, with three one-hour turnaround servicings (which could be skipped with aerial refueling). The AV-8B could ferry from the El Toro, California MCAS to Diego Garcia in the Indian Ocean in twenty-nine hours (twenty-four hours flight time).

4. The AV-8B is NATO compatible. It can accept consumables and weapons available at NATO bases, and it is compatible with NATO communications and aircraft turnaround servicing facilities.
5. Starting power, electric power, and hydraulic power are all provided by onboard systems. The AV-8B also has an onboard oxygen generating system which eliminates the transfer and filling requirements for high pressure liquid oxygen bottles.

No single tactical aircraft combines all of the desired operational capabilities for effective rapid deployment, but the AV-8B is a light attack aircraft with excellent supportability and a degree of basing flexibility that is unique to V/STOL aircraft [Ref. 39: p. 6].

The overall Navy Department aircraft procurement situation at the time of the AV-8B controversy was not very good. LtGen Miller stated in 1980:

Naval aviation needs about 320 aircraft per year to maintain its present force level. Since Marine aviation is about one-third of Naval aviation, we need about 100 aircraft per year to keep our aircraft inventory at its present level. With Navy procurement way below the 320 aircraft needed annually, it's fairly widely recognized that if the Navy and the Marine Corps, in the near future, don't start building up procurement each year, we simply won't be able to perform our mission. [Ref. 40: pp. 46-47]

The Marines were already starting to feel that pinch. Because the Office of the Secretary of Defense (OSD) cut AV-8B program funding in half during the FY1979 Program Objective Memorandum (POM) portion of PPBS, the Marine Corps

planned to reduce the number of AV-8A's in each squadron from twenty to fifteen by the end of FY79 and at the same time increase the number of A-4M's in each squadron from sixteen to nineteen in order to keep the light attack force at 140 aircraft [Ref. 41: p.49]. But that would have been a difficult solution to carry out because the A-4M was going out of production in February 1979 [Ref. 33: p. 390]. There was no question that the Navy and the Marines needed many more modern aircraft. The controversy was over what types of aircraft were going to fill those needs.

In 1977, Secretary of Defense Harold Brown ordered the Marine Corps to do a cost/effectiveness study of the A-18 and AV-8B attack aircraft. Later that study was moved to the Secretary of the Navy's Office for Programs and Analysis [Ref. 42: p. 18]. The Secretary of the Navy formed a Navy-Marine team which included members of the OPNAV and Marine Headquarters staffs, Naval Air Systems Command, and the Center for Naval Analyses to do this study [Ref. 43: p. 5082]. The study is entitled An Evaluation of the Comparative Cost-Effectiveness of the AV-8B and A-18 Aircraft In Support of Marine Corps Light Attack Requirements Including Amphibious Operations, and is commonly known as the 8-18 Study. The study was based on the V/STOL concept of operations, including logistics support , developed by the Marine Corps and tested by the operational experience gained with the AV-8A, and was keyed to close air support of an amphibious operation. Amphibious scenarios included in the study were the Middle East, Korea, Jutland, the Persian Gulf, and various sea lines of communications actions. Sensitivity analyses were run to vary operating modes, weapons used, target mixes, and target appearance rates. The conventional, centralized offensive air support by CTOL aircraft from an expeditionary (SATS) or carrier

(CV) airbase was compared with dispersed site operations of V/STOL aircraft from both CV and air-capable amphibious ships and V/STOL sites and facilities ashore. [Ref. 43: pp. 5082-5083] The key points of the cost analysis portion of the study were [Ref. 43: pp. 5084-5085]:

1. The cost analysis compared the mix of twelve F-18 fighter-attack squadrons and eight AV-8B light attack squadrons requested by the Marine Corps with the twenty squadrons of F-18's proposed by the Secretary of Defense.
2. Ten- and fifteen-year life cycle costs were examined.
3. The factors that tended to drive up the cost of the A-18 and drive down the cost of the AV-8B were:
 - a) The large airframe of the A-18 and small airframe of the AV-8B.
 - b) Two engines in the A-18 and only one engine in the AV-8B.
 - c) A medium amount of avionics in the A-18 and a low amount in the AV-8B.
4. The factors that tended to drive up the cost of the AV-8B and drive down the cost of the A-18 were:
 - a) A buy of 1160 A-18's versus a buy of 366 AV-8B's.
 - b) The research and development costs of the A-18 were sunk costs, whereas the research and development costs of the AV-8B were still ahead.
 - c) The A-18 has common siting (CV or airfield) while the AV-8B is operated in dispersed detachments (sea base, forward sites, facilities, etc.).

The main points of the effectiveness analysis portion of the study were [Ref 43: pp. 5085-5087]:

1. Factors that make the A-18 an effective aircraft:
 - a) It carries a larger payload.
 - b) It has longer range and endurance.

- c) It has a very accurate ground attack weapons system.
 - d) It is a swing fighter, that is, it can be used in an air-to-air role as well as close air support.
 - e) It has increased reliability because of twin engines.
2. Factors that make the AV-8B an effective aircraft:
 - a) It operates closer to the supported units.
 - b) It utilizes ground loiter rather than air loiter.
 - c) It has the shortest response time.
 - d) It has greater deployment flexibility.
 - e) Its base survivability is greater.
 3. Required response times for three targets were derived from many previous studies and combat experience. The response basis was that the attacking aircraft must respond within 30 minutes or less to have any effect. Target value begins to decay when the target begins to inflict casualties on supported units.
 4. One measure of effectiveness was based on a comparison of target value kills versus the appearance on target rate of each aircraft. In this comparison the AV-8B was based at an average distance of approximately thirty-seven miles from the Forward Edge of the Battle Area (FEBA) utilizing ground loiter from forward sites, while the A-18 was based an average of 125 miles from the FEBA utilizing air loiter near the FEBA. This comparison showed that a forward based small aircraft is equal to a large rear based aircraft in effectiveness with reduced logistics costs.
 5. Another measure of effectiveness was conduct of operations from bases under threat raids. In this comparison the bases used by the two aircraft were subjected to runway interdiction raids using airbase detection

probability results from NATO flight tests. As a result of the raids, the A-18 effectiveness was degraded approximately 30% and the AV-8B effectiveness was only degraded by about 12%. This comparison showed that the reliability of sortie generation capability is much higher with V/STOL aircraft utilizing a dispersal concept in a contested area.

6. Another measure of effectiveness studied was the relative effectiveness compared to the fraction of the the light attack force used for close air support and interdiction. The total force used for the study had a light attack force of 160 aircraft, which was the Marine Corps' objective at the time the study was done. If the force was used totally for anti-air warfare, meaning no aircraft used for close air support or interdiction, then the A-18 mix was more effective because of its fighter capability. As the light attack force is committed to close air support and interdiction missions to the extent of about 40% to 50% of all sorties, then the AV-8B mix becomes superior and continues to be better as the commitment to close air support and interdiction is increased. The Marine Corps normally programs 85% of its light attack sorties for close air support.

The main conclusions drawn from the 8-18 study were [Ref. 44: pp. 7-8]:

1. The life-cycle costs of the two alternatives were equal for both the 10-year and 15-year cycles.
2. The overall relative effectiveness of the two systems is heavily dependent on scenarios and employment assumptions.
3. In the close air support target scenario analyzed, the AV-8B was substantially more effective and, because of

its flexibility in basing, is more likely to be more effective on a scenario independent basis.

With all their confidence in the AV-8B program the Marine Corps continued to push the program in the Pentagon. The Marines also carried the fight on to Capital Hill in testimony before various committees of both houses of Congress. Marine general officers repeatedly stressed the Marine Corps view of the AV-8B program to Congress. General Louis H. Wilson, when he was the Commandant of the Marine Corps, testified about what the Harrier's unique V/STOL capability added to responsiveness, survivability, and the ability of the Marines to carry out their mission:

We feel that the AV-8B, a V/STOL capability and the only V/STOL development in this nation, would provide effectively for the modernization of our light attack force. I am pleased to report that prototype development of the YAV-8B has been progressing smoothly... Regrettably, funding constraints required that the R&D funds for continuing the AV-8B program be deleted from the fiscal year 1980 budget. [Ref. 45: p. 930]

and

I believe the AV-8B is a technology which is the only V/STOL in this nation now. We believe it is a fine aircraft for the Marine Corps. It gives us a new dimension for close air support for the young Marine on the ground... It has one and a half times the capability of the A-4 which we have now... We know that the enemy, when we move in anywhere, will go for the airfields. This plane can provide support without airfield support. [Ref. 45: p. 940]

and

The V/STOL capability resident in the AV-8B is crucial to the ability to project Naval power ashore through forcible entry without being tied to airfields. This V/STOL capability enables the Marine Corps to rapidly phase its Close Air Support (CAS) assets ashore. Additionally, V/STOL capability permits the exercise of forward site basing options which will place CAS assets in close proximity to the forward lines. Close proximity can be directly translated to reduced response time - CAS directly on call by the supported ground commander. Supported in this way, the ground commander can concurrently increase the combat capability and survivability of the young Marines on the firing lines. [Ref. 45: p. 1013]

In response to questions from members of Congress, General Wilson stressed how important the Advanced Harrier was to the Marines and what priority the Marine Corps gave the AV-8B relative to the F/A-18:

Senator Hart. General, if fiscal reality compelled termination of either the AV-8B or the F-18, in your personal opinion, which program should be terminated, if it is necessary to terminate one of them?

General Wilson. Well, that is like saying which of your children are you going to give up, Senator Hart.

Senator Hart. We can be cruel.

General Wilson. I need not elaborate on that. Of course we obviously need the F-18 as much as we need the AV-8B for our attack aircraft. But I testified last year, and I believe this still holds, if I am pushed to the point, toward which I am now being pushed, we could hold off on our modernization of our fighters. Therefore, I would take the AV-8B.

Now on the other hand, that implies that there is going to be another fighter, and we have no indication now that there is anything better than the F-18 coming down the line; so I am equivocating.

Senator Hart. I think I can spot an equivocation. Thank you. [Ref. 46: p. 535]

and

Senator Cannon. General Wilson, what priority is the AV-8B program overall relative to other Marine Corps' programs?

General Wilson. The AV-8B program was and would be by highest priority for aviation programs. [Ref. 46: p. 545]

and

Senator Munn. General Wilson, in your opinion what is the result of the Marines' eight years experience of operating the AV-8A Harrier?

General Wilson. We have conducted AV-8A operations around the world, both ashore and at sea. We have operated the Harrier in the deserts of California, the tropics of the Philippines, the Arctic conditions of the North Atlantic and Canada, and in Korea, Australia, Germany, Denmark and Kenya. These operations prove to our satisfaction the advantages of V/STOL in close air support anywhere, anytime from the most austere bases, with high sortie rates; immediate response to the needs of Marines on the ground; conduct of operations from damaged airfields; increased survival of aircraft and crews by dispersion to several sites.

Our operational experience tells me, in short, that the Marines and this country need the AV-8B. [Ref. 46: p. 553]

The Commandant's testimony was reinforced by testimony given by Lieutenant General Thomas H. Miller, Deputy Chief of Staff of the Marine Corps for Air under General Wilson. LtGen Miller testified about the importance of the AV-8B program as a part of Marine Corps' V/STOL objectives:

Consistent with our experience with the helicopter in Korea and South Vietnam, the basing flexibility offered by the helicopter's V/STOL characteristics clearly point the way for improving the responsiveness of our vital heavy airborne fire support for the ground combat Marine. In 1971, some 8 years ago, the Marine Corps was provided and commenced operating the free world's only high performance V/STOL tactical aircraft the British Harrier, or AV-8A. After 8 years of operating this unique aircraft in almost every known environment, both in support of ground forces and in many other missions on land and at sea, the Marine Corps considers this type of aircraft system to be most vital and of unqualified success. The AV-8B was envisioned to continue the evolutionary development of an improved version of the AV-8A in the same manner that has been done with conventional fixed-wing aircraft since the Wright Brothers first flew, and with helicopters since they were first used in the Marine Corps in the late 1940's and early 1950's. [Ref. 47: p. 994]

As the controversy continued over several years, General Wilson retired and the Marine Corps got a new Commandant, General Robert H. Barrow. The new Commandant continued to express the Marine Corps view of the AV-8B to Congress. In 1980, General Barrow repeated in his testimony how important the Marine Corps thought the Advanced Harrier was to them:

Senator Stennis. General Barrow, is the AV-8B program of a lower priority to the Marine Corps than all of the programs included in the submitted fiscal year 1981 budget?

General Barrow. It certainly is not, Mr. Chairman. The AV-8B remains our highest priority aviation program. Unfortunately, funding constraints make it impossible for everyone in the Department of Defense to agree on the priority of many programs. [Ref. 48: p. 854]

and

Senator Cannon. General Barrow, does the Marine Corps fully support the AV-8B program?

General Barrow. The Marine Corps views this program as essential to modernize and maintain the Marine Corps light attack force through the remainder of the century, and is the highest priority program in Marine Corps aviation... The primary mission of this force is to provide close air support to the ground combat element of the Marine Air Ground Task Force; therefore, the aircraft in its present configuration is optimized for that mission. [Ref. 48: p. 860]

The Marine Corps' priority for the AV-8B relative to the F/A-18 and its opinion of which aircraft was better suited for Marine Corps requirements remained consistent also:

Senator Cannon. General Barrow, what would the Marine Corps be willing to give up in the fiscal year 1981 budget to fund the requirement for the AV-8B?

General Barrow. We feel that the cost of the F/A-18's earmarked for the Marine light attack force should be used to fund the AV-8B requirement. [Ref. 48: p. 860]

and

Senator Nunn. What is your assessment of the AV-8B program to date and your position on its value to the Marine Corps' ability to perform your missions?

General Barrow. The Flight Demonstration Program at Naval Air Test Center Patuxent River has proved the technical competence of the YAV-8B. The aircraft has met or exceeded all contract demonstration points; in short, it has shown in flight that it can do everything we want it to do. All the characteristics of the AV-8B - range, payload, responsiveness, flexibility, to name but a few - are just what we are looking for in a light attack aircraft. My position, Senator Nunn, remains the same: I want an all V/STOL light attack force of AV-8B's for the Marine Corps because I think it will fill our requirements as no other aircraft can. [Ref. 48: p. 863]

and

Senator Thurmond. General, would you compare the AV-8 and the F-18 ground attack capabilities.

General Barrow. First, the ground attack capabilities of the AV-8B must be associated with the primary mission for which the aircraft has been designed, that of close air support. The aircraft incorporates systems and capabilities based on data gained through years of close air support experience and extensive employment of the V/STOL concept via the AV-8A. The effectiveness provided by the passive and highly accurate Angle Rate Bombing System (ARBS) will give the AV-8B a distinct advantage over the F/A-18 in the Close Air Support role. The basing flexibility, both aboard ship (CV, LPH, LHA, LPD) and ashore (unprepared

sites, damaged runways, roads, etc.), and its capability to respond to the ground commander provides the AV-8B an effectiveness not available from the F/A-18. A pointed example of the AV-8's flexibility resulted from the Harrier's performance in the recent exercise "Display Determination" in Turkey. While conventional aircraft were "weathered in" for two days at a main airfield (burdened as well with logistical air traffic saturation and simulated enemy interdiction strikes), the AV-8's staged from an off shore LPN to remote forward sites and provided continuous air support throughout the period. [Ref. 48: p. 905]

and

Mr. Edwards. Has the Marine Corps solicited the opinions of its aviators on this subject? Do the men who will fly in combat agree that the AV-8B is the way to go?

General Barrow. The Marine Corps, like other services, develops weapon system requirements on the basis of the current and projected threat and technology, among other things. The staffs which develop these weapon systems are made up of experienced aviators who will return to the fleet when they leave this area. In short, new aircraft are guided through the wickets of development and procurement by the same people who expect to fly them in combat. The pilots who have been flying the AV-8A for the past nine years are more than enthusiastic about AV-8B. [Ref. 49: p. 663]

C. CONGRESSIONAL SUPPORT FOR THE MARINE VIEW

Congress responded positively to the Marine Corps' presentation of its view of the AV-8B decision by restoring funding requested by the Marines that had been cut from the President's budget by OSD when the controversy first began, and later by adding procurement funds to the President's budget when none were requested. When the Department of Defense first took action against the Advanced Harrier program by cutting its funding in half for fiscal year 1979, Congress returned it to full funding [Ref. 34: p. 53]. This set the pattern for years to follow, whenever the Marines' request for AV-8B funding was cut from the President's budget, that funding would be restored by Congress. The House of Representatives Committee on Appropriations report in 1980 stated:

Witnesses representing the Marine Corps testified that the Harrier program is one of its highest priorities for fiscal year 1981. The Congress has, for several years, supported the development of this aircraft that is now ready for production... The Committee, in continuing support for this very important program, recommends \$90,000,000 for long-lead procurement which has been included in the fiscal year 1981 authorization conference agreement. [Ref. 50: p. 248]

As has been the case in the past, the Navy did not request funds for the AV-8B, and the Marine Corps testified to the need for developing this V/STOL capability. It continues to be the Committee's belief that vigorous pursuit of the AV-8B is the only viable and logical way of obtaining a V/STOL aircraft for our forces in the near future. [Ref. 50: p. 307]

Some senators were concerned about what impact termination of the AV-8B program would have on the future of V/STOL technology in the United States. Senator Harrison A. Williams, Jr. said, "We would yield the promising V/STOL field to Great Britain and the Soviet Union." [Ref. 42: p. 18] Senator Williams was also concerned about terminating the program for an aircraft manufactured in the United States:

Not only will this mean more jobs for Americans, but it will insure that we have the technology and the manufacturing capability for V/STOL aircraft in the United States. [Ref. 42: p. 18]

Other senators were concerned about the AV-8B program because they saw a future for V/STOL aircraft in the U.S. Navy. Senator Patrick Leahy said, "While the Advanced Harrier is currently planned as a Marine Corps aircraft, its real importance in the future will be as a naval aircraft." [Ref. 42: p. 18]

D. THE U.S. NAVY VIEW

The U.S. Navy view of the AV-8B program had many aspects. The Navy was concerned about their own plans for integrating V/STOL or VTOL aircraft into the Navy, and what impact the AV-8B program might have on those plans. Within

the wide scope of naval aviation, the Navy was concerned about what impact the AV-8B program would have on other aviation programs providing aircraft for strictly Navy use, as well as the needs of Marine Corps aviation, a part of naval aviation.

The Navy's plan for incorporating their own V/STOL aircraft has had many ups and downs. The Chief of Naval Operations (CNO) in 1977, Admiral James L. Holloway III, stated:

In the spring of 1975, I reviewed the status of V/STOL and V/STOL ship programs... I concluded that the failure of V/STOL resulted primarily from the fact that the V/STOL programs were competing for aviation program funds with patrol and carrier planes. [Ref. 51: p. 21]

So, even though the V/STOL program was having a tough time getting going in the Navy, the benefits of having all sea-based, manned, tactical aircraft converted to V/STOL were well understood [Ref. 51: p. 21]. These benefits were:

1. Manned tactical air could be expanded throughout the fleet to a much greater degree, enabling surface combatants to attain new capabilities.
2. The design of future carriers could become much more flexible without the requirement for angled decks, overhang, arresting gear, and high-capacity catapults.

The Deputy Chief of Naval Operations (Air Warfare) conducted a study, completed in the spring of 1976, that concluded it was possible to develop and produce V/STOL aircraft which could fulfill the future requirements of Navy sea-based, manned, tactical aircraft [Ref. 51: p. 22]. Based on this study and the conclusions made by the CNO, a plan was developed that called for the replacement of conventional aircraft models, at the normal expiration of their service life, with V/STOL follow-on aircraft. Those follow-on aircraft would use the current inventory of CTOL aircraft carriers until an all-V/STOL naval air force made pure V/STOL

carriers feasible. The Navy had a full inventory of CTOL carriers, and these could be used just as well for V/STOL operations as V/STOL airplanes were phased in, but a pure V/STOL carrier would not be able to operate CTOL aircraft. Another long-term Navy objective to be accomplished with this plan was to reduce the number of different aircraft types in the Navy and the Marine Corps [Ref. 51: p. 22]. This would be accomplished by limiting fixed-wing V/STOL designs to two basic types [Ref. 52: p. 44 and Ref. 51: p. 23]:

1. Type A - fairly large, subsonic, multimission, multi-place, and sensor-carrying for the Anti-Submarine Warfare (ASW), Carrier On Board Delivery (COD), Airborne Early Warning (AEW), and tanker missions.
2. Type B - smaller than Type A and supersonic, for the fighter and attack missions.

The Navy was divided on the program of V/STOL development [Ref. 52: pp. 44-45]. The surface Navy was enthusiastic about V/STOL because of the new capabilities it would bring to the surface fleet. The surface combatant's offensive power could be increased by mating a V/STOL over-the-horizon detection, tracking, and targeting capability, carried on and launched from their own ships, with surface-launched, air-targeted, long-range missiles fired from their ships. This would extend their offensive capability far beyond what was possible using only radar.

While the surface Navy was in favor of V/STOL, Naval aviators had mixed views of V/STOL developments. Many Naval aviators were not in support of V/STOL because of a variety of reasons:

1. There were conservatives who did not want to change from a proven system (CTOL aircraft, large carriers) to a new, unproven one (V/STOL aircraft, small carriers).

2. Some viewed V/STOL as a threat to carrier aviation's place of supreme importance in the Navy, and they thought this would somehow decrease their career prospects.
3. Some felt that the future of naval aviation was in projection of power ashore as Naval aviation had operated in World War II in the Pacific, in Korea, and in Vietnam. CTOL aircraft can carry large payloads over long ranges and would be superior to present V/STOL aircraft in such a situation.

Other naval aviators were in support of V/STOL aircraft and the smaller carriers that would carry them, because it was becoming increasingly evident that each large CTOL carrier represents an extremely high value target to the enemy, and that too much combat power is concentrated in one ship with these large modern carriers [Ref. 52: p. 46].

This new V/STOL plan of the Navy's was, of course, a long range plan because the V/STOL Type A and B aircraft did not exist, and would not for fifteen or twenty years. Some planners in Washington were in favor of the more immediate option of having the Navy concentrate on the development of a Harrier derivative aircraft for purely naval roles [Ref. 52: p. 47]. In 1977 a study was presented to the Secretary of the Navy, W. Graham Claytor, Jr., that looked into the feasibility of using a Navy version of the AV-8B. The study looked at what avionics would be necessary for the AV-8B to serve in several different roles with air-to-surface and limited air-to-air capability, as well as what the propulsion system requirements were, what aircraft performance was needed, and what the cost estimates were for development and production [Ref. 42: p. 18]. The estimated cost for development of the "Navalized" Harrier was \$1.2 billion, \$285 million for the engine and \$933 million for the

airframe [Ref. 53: p. 5107]. This proposed Navy version of the Harrier was called the AV-8B+ (AV-8B Plus). If the Navy had decided to adopt the AV-8B+, the Marine's position on the Advanced Harrier would have been strengthened because 495 more AV-8B's would have been produced and their unit cost decreased. But, the Navy did not pursue the AV-8B+ for several reasons. One reason was that funding constraints would have made it very difficult for the Navy to enter the AV-8B program while financing the F/A-18. Senior Navy officials said that the AV-8B is a credible light attack aircraft for the fleet, but it doesn't fit because it competes with the F/A-18 for scarce funds [Ref. 54: p. 56]. The possibility of a Navy AV-8B+ surfaced again later when the Navy began to make plans for the reactivation of four battleships. There was a possibility that the Navy might procure the AV-8B+ for use on the battleships. The Senate Armed Services Committee added money to the Fiscal Year 1982 authorization bill for the development of systems for the AV-8B+, but the House Armed Services Committee did not [Ref. 55: p. 60]. There are still no firm plans for the AV-8B+. One of the major reasons the Navy was reluctant to support the Marine's AV-8B program was its concern that it would be forced into an AV-8B+ aircraft that it did not really want [Ref. 42: p. 18]. One of the reasons that the Harrier might not be the right design for the Navy is that the basic Harrier design has physical limitations that could keep it from being fully exploited into the supersonic region. Also, the AV-8B's lift/cruise design gives it very good performance with a short take-off, but limits its performance in vertical take-off. The Navy would rely more on vertical take-off capability for operations from ships such as frigates and destroyers. [Ref. 52: p. 47] A third reason for the reluctance to join the AV-8B program is the Navy's

range and payload requirements. The Marine Corps can live with the reduced range/payload of the AV-8B relative to CTOL aircraft. Reduced range/payload is the trade-off for V/STOL capability. Because the basing flexibility gained with the Harrier allows it to perform its close air support mission more rapidly it is suited to the Marine Corps, but the Navy's mission requirements demand greater ranges and larger payloads on the open sea where a basing trade-off is not possible. [Ref. 12: pp. 25-26]

A main concern of the Navy, at the time the AV-8B controversy was going on, was the problem of maintaining the force level in Naval aviation discussed before. While the Navy essentially supported the Marines in their fight for the AV-8B, the Navy was waging its own battle with the Department of Defense over what aircraft it was going to acquire for its own needs. The Navy was concerned about what impact the Marine's AV-8B program would have on other programs providing Navy aircraft. The Department of the Navy preference for Naval aviation aircraft in 1977 was to have an all F-14 fighter force, an A-18 Navy light attack force, an F-18 Marine fighter force, and an AV-8B Marine light attack force [Ref. 56: p. 144]. Just two years later, severe money constraints forced the Navy to look at other options, including a request to terminate the F/A-18 program [Ref. 57: p. 41]. But the program was not terminated, and the Navy got the F/A-18 anyway. Under Secretary of the Navy R. James Woolsey, in discussing the continuation of the F/A-18 program, stated:

Inventories must, of course, be sustained, but the dominant consideration is best use of limited resources to buy the mission capability required to meet the projected threat according to rational priorities. [Ref. 58: p. 42]

The Navy did not believe that the F/A-18 was an affordable program, and rather than let the aircraft inventories become

depleted, because the numbers of aircraft needed could not be afforded, they developed several options to get airplanes they thought would allow them to accomplish their mission, while staying within the tight budget constraints being imposed on them at the time by the Department of Defense. The Navy's basic plan was to by-pass the F/A-18, filling requirements with less costly aviation programs until V/STOL replacements could come along [Ref. 57: p. 41]. Under this plan the Navy would have all F-14's for its fighter force, keep A-7's for its light attack force, keep F-4's as long as possible for the Marine fighter force, and acquire AV-8B's for the Marine light attack force. The Navy held that the F-18 was not a lower cost substitute for the F-14, but a lower capability substitute. In a memorandum to the Secretary of Defense, Woolsey said, "...10 F-14's are as good or better than 12 F-18's." [Ref. 58: p. 43] The Navy also maintained that the only advantage that the A-18 had over the A-7, the light attack aircraft then in service with the Navy, was greater agility in post-attack retirement (getting away from the target area after delivering its ordnance), which the A-18 gained at a significant trade-off in range and payload compared to the A-7 [Ref. 58: p. 43]. The Navy backed the Marine Corps in its choice of an F-4 and AV-8B mix over an F-18 and A-18 mix if the Marines could not have its first choice of F-18's and AV-8B's. The Navy maintained that even though it really didn't like the idea of extending the life of the F-4's with another Service Life Extension Program (SLEP), it was the best option that could be afforded. Because the Marine fighter mission was more one of maintaining air superiority than initially establishing it, and because newer missiles that were soon to be in service would shift capability emphasis from the platform (F-4 or F-18) to the weapons being carried, the Navy felt the F-4

could continue to fulfill the Marine fighter requirement [Ref. 58: p. 43]. The Navy's position on the AV-8B was stated by Mr. Woolsey in his memorandum to Secretary Brown:

We, too, respect and are impressed by the Commandant's strong conviction in regard to the AV-8B. It is of central importance to our recommendation that the AV-8B is the right choice for the Marine light attack force... We concluded that, given the purpose for which the Marine light attack force is intended and the tactics and methods of applications which the Marines, based on their plans and experience, expect to use, the Commandant's conviction is justified. The AV-8B is definitely preferable for the Marine light attack role. [Ref. 58: p. 43]

The main point of the Navy's plan to terminate the F/A-18 program was that their alternative would save \$2 billion over the following five years. The Navy's position was summed up as follows:

the F/A-18 provides some capabilities that we would like to have, in light of the fiscal constraints we surely face, it is far preferable to terminate it than to suffer the disproportionate loss in other aviation and non-aviation programs which otherwise seem inevitable. [Ref. 58: p. 44]

Even though the Chief of Naval Operations and officials in the office of the Secretary of the Navy were in support of the AV-8B for the Marine Corps, there were other Navy officials that were not sure that the Navy could afford the Advanced Harrier. These officials were looking ahead to the mid-1980's and they were worried about how the Navy was going to afford several types of aircraft during that time. Vice Admiral F.C Turner, Deputy Chief of Naval Operations (Air Warfare) said:

We have been faulted in the past for buying too many types, too small a buy, and so forth. That was clearly true, but there are some good reasons why that occurred. First, as we all know, we have two services, the Navy and the Marine Corps. Years ago, we could afford to have more different types, but with the increasing threat, the complexity of weapons systems, of weapons, antiship cruise missiles and the like, the cost of aircraft to meet the threat has gone up astronomically. We can no longer afford diverse and different types. [Ref. 59: p. 959]

One of the concerns was that the first substantial increase of AV-8B procurement was in 1983, which was also a big year for F/A-18 procurement [Ref. 60: p. 16]. Funding for the AV-8B complicated Navy planning for aircraft procurement. There were several options for how the AV-8B would be funded if the program were approved [Ref. 61: p. 75]. The Navy was hoping that the money would come from outside the Navy budget altogether. Another option was that the money would come from Navy programs other than aviation and not complicate the aviation procurement picture further. If the money had to come from within the aviation programs there were several options:

1. Transfer three F-4 squadrons from the Marines to the Navy. A corresponding adjustment would allow the Navy to receive the first F/A-18's.
2. Cutback or stretchout the F/A-18 procurement.
3. Reduce procurement of the CH-53 helicopter for the Marines.

The analysis of the costs involved in the F/A-18 and AV-8B programs had shown that the life cycle costs of the A-18 and the AV-8B options for the Marine Corps were about equal, but there was a problem with funding because more money was needed earlier in the AV-8B program. As one Navy official put it, "We do support the Marine's requirement, and with the life-cycle costs, the AV-8B will pay for itself, but it's the front-end investment that's choking us." [Ref. 62: p. 56]

Again in 1980 severe fiscal constraints started the Navy thinking about cancelling the F/A-18 program. Navy Secretary Edward Hidalgo said: "Escalating costs of the F/A-18 have raised serious questions in my mind including the disturbing possibility of canceling the F/A-18." [Ref. 63, p. 22] As the possibility of canceling the F/A-18

program was being weighed, even the Office of Management and Budget (OMB) was analyzing options for aircraft to replace the F/A-18. The replacements studied by OMB were:

1. The F-14. 725 aircraft at a cost of \$22.1 billion.
2. The AV-8B. 322 aircraft at a cost of \$6.1 billion, including research and development costs.
3. The A-7. 36 of the "E" model A-7's then in production for \$400 million and another \$5.9 billion for 453 twin-engined versions including research and development costs.

The total cost of the 1536 aircraft in the above option was estimated at \$34.5 billion, which had to be weighed against the current estimate for the F/A-18 at that time of \$31.5 billion for 1300 aircraft. [Ref. 64: p. 18]

With their concerns about Naval aviation overall, concerns about what aircraft the Navy could get for its own use, and concerns about the future of Navy V/STOL, Navy officials also went to Capital Hill to testify before Congress.

Some of the testimony was in strong support of the AV-8B program, and some was not so strong. An example of the latter was given by Vice Admiral F.C. Turner, the Deputy Chief of Naval Operations (Air Warfare) in 1979:

Senator Cannon. Are you saying, then, when you say you support it, support the AV-8B, but it sounds to me like you don't support it very strong because you can see that it has got to come out of your hide someplace, is that it?

Admiral Turner. That is essentially it...

Senator Levin. Based on the affordability question, would it be fair to say that you concur in that decision of the Department of Defense? [To cancel the AV-8B]

Admiral Turner. As a representative for the President's budget and the decisions which have been reflected in the Department, I would have to say "yes." [Ref. 59: pp. 987-988]

Admiral Hayward, the CNO, testified about the AV-8B on several occasions and he tried to support the Marine Corps while at the same time still not showing much enthusiasm for the AV-8B as a future aircraft for the Navy:

The Navy has continuously supported the Marine Corps requirement for the AV-8B and recognizes the high priority the Commandant places on the program... From what I have seen to date, the V/STOL concept offers great potential for enhancing the Navy's future sea based air capabilities. I would like to withhold my final judgement on both near term decisions and the future role of V/STOL until I have completed my assessment of all the factors that impact on the scope and direction of future sea based air programs. As I have stated in the past, I fully support the AV-8B for the Marine Corps. [Ref. 65: p. 846]

The Navy will continue to support development of the AV-8B as being a sound investment to sustain the momentum of V/STOL technology irrespective of a decision for AV-8B procurement. [Ref. 66: p. 662]

Senator Nunn. Do you think that the F-18 is a viable substitute for the Advanced HARrier, given the peculiar requirements of Marine aviation?

Admiral Hayward. Yes, either aircraft can fulfill the Marine requirement for a light attack aircraft. [Ref. 67: p. 549]

Senator Hart. When will the first American-built V/STOL aircraft achieve IOC, in current plans if the AV-8B is cancelled?

Admiral Hayward. While I supported the AV-8B for the Marine light attack role, funds permitting, I did not consider the technology embodied in this aircraft a forward step in our long range effort to develop a seabased V/STOL fully capable of naval roles and functions. [Ref. 67: p. 567]

In spite of a Department of Defense view that opposed both the Navy and the Marine Corps, opponents of the AV-8B program were overridden and the program was continued by Congress and still continues today.

V. THE OFFICE OF THE SECRETARY OF DEFENSE VIEW

A. WHEN THE CONTROVERSY BEGAN

Each year the Secretary of Defense makes a statement to Congress on the status of his department, the budget for the coming year, and the current Five Year Defense Plan (FYDP). From 1970 until 1977, all the Secretaries of Defense supported the acquisition of the Harrier by the Marine Corps [Ref. 68: p. 60; 69: pp. 93, 183; 70: p. 83; 71: p. 69; and 72: pp. 145, 148-149]. In his statements of 1976 and 1977, Secretary of Defense Donald H. Rumsfeld stated the Department of Defense plans for the Advanced Harrier:

The Marine light attack force will consist of five squadrons of A-4H's and three squadrons of AV-8A's through fiscal year 1981. Starting in fiscal year 1982, the Marines plan to replace all of their light attack aircraft with the AV-8B. [Ref. 73: p. 150]

and

The AV-8B development program aims at building upon the AV-8A program to produce a vectored thrust attack aircraft superior to the A-4H and superior to the AV-8A in STOL and V/STOL performance. [Ref. 73: p. 153]

and

...plans for upgrading and modernizing Marine tactical aviation include the introduction of the F-18 for the fighter/attack mission and the AV-8B for the close air support mission. [Ref. 74: p. 221]

Support for the AV-8B stopped when Harold Brown became the Secretary of Defense under President Jimmy Carter. Secretary Brown did not seem completely opposed to the Advanced Harrier program when he first took office. In his first statement to the Congress in 1978 he stated:

Plans for upgrading and modernizing Marine aviation include introduction of the F-18 for the fighter/attack mission and additional procurement of the A-4H. There is also a possibility that we will procure some quantity of AV-8B's. [Ref. 75: p. 216]

Mr. Brown expressed a wait-and-see attitude about the AV-8B, he said:

The FY79 program includes development of two prototype YAV-8B aircraft and additional R&D funds for further AV-8B subsystem development. Procurement is deferred pending a determination that the YAV-8B's meet performance goals and a Defense Department assessment that the AV-8B offers significant advantages over conventional aircraft such as the F/A-18. [Ref. 75: p. 221]

However, by the next year, Secretary Brown had completely made up his mind about the AV-8B. In his statement to the Congress on the FY1980 Defense Budget, he said:

Modernization of the Navy and Marine Corps tactical air forces will be accelerated during the five year period by the introduction of the moderately priced F/A-18 aircraft. The F/A-18 program will reduce the number and types of aircraft in carrier and Marine aircraft wings by using a common system for the fighter and light attack missions, resulting in reduced operating and support costs... In light of expected limitations on funding for procurement of Marine and Navy aircraft in the 1980's, and the need to purchase larger numbers of such aircraft, we have decided to terminate funding for AV-8B research and development. While this aircraft does appear to have some potential for Marine Corps close air support missions, it appears that its measurable advantages over a conventional aircraft, such as the dual-mission F/A-18's, may be minimal. In any event, there are advantages in concentrating on fewer types of aircraft. [Ref. 76: pp. 188-189]

The fiscal year 1980 funding for the AV-8B, requested by the Marines and deleted by the Department of Defense, was restored by Congress. In spite of this support of the AV-8B shown by Congress, Mr. Brown remained in opposition to the program, and he expressed his opposition again in his 1980 statement to Congress:

Although the V/STOL performance of the AV-8B gives it unique capabilities, it is not as capable as the F/A-18 in most close air support missions and is markedly inferior in air-to-air and interdiction missions. Because we wish to maintain Navy and Marine Corps force levels and performance at a reasonable cost, we have decided that proceeding with the AV-8B program is not justified at this budget level and have not included funding for it in the FY81 budget. However, we will continue to work with the United Kingdom to determine whether there exists the potential for a common U.S.-U.K. venture which would procure enough AV-8B's to change our view about continuing the program. [Ref. 77: p. 200]

The Marine Corps wanted the AV-8B very badly. The Navy supported the Marine's Advanced Harrier program. The 8-18 study had concluded that, compared to the A-18, the AV-8B was the best aircraft for the close air support mission, and would cost no more than the A-18. With all of this going for the Advanced Harrier program, why was the Secretary of Defense so set against it?

B. THE OSD CASE AGAINST THE AV-8B

In 1977 Defense Secretary Harold Brown had made a decision to delay the procurement of AV-8B's and buy more A-4H's instead. A "reclama" to this decision was made by the Marines which prompted Mr. Brown to order the comparative analysis of the AV-8B and the A-18. A meeting was held in November 1977 between Secretary Brown, Secretary of the Navy W. Graham Claytor, Jr., and Commandant of the Marine Corps General Louis H. Wilson. The 8-18 study was discussed at length during that meeting, and one defense official said, "I gather things did not go well for the Marines." [Ref. 78: p. 30] Despite the fact that the Navy/Marine Corps study showed that the AV-8B was more effective and no more costly than the A-18, Mr. Brown was still not convinced that the AV-8B should be approved. Not satisfied with the results of the 8-18 study, Secretary Brown directed his Assistant Secretary of Defense for Program Analysis and Evaluation (PA&E), Russell Murray II, to conduct another study on the two aircraft [Ref. 79: p. 47].

The position of Assistant Secretary of Defense for PA&E is an influential position. The duties of the PA&E office were outlined by Mr. Murray when he testified before Congress at his own nomination hearing:

As the Assistant Secretary of Defense for Program Analysis and Evaluation, my main role would be to advise the Secretary of Defense on issues involving force structure, choices between alternative

weapon systems, scenarios on which our planning should be based, the capabilities of alternative forces and what they cost, and similar matters of central importance in defense planning.

Some parts of such issues can be resolved, or at least illuminated, through quantitative analysis. The rest transcend the limits of analysis, and thus must be resolved through judgement. I would confine the work of this office to the former: analysis. Judgements, to the extent that they are made within the Department of Defense, are the responsibility of the Secretary of Defense, not this office.

Analysis can be a powerful tool, and thus this analytically based office will no doubt be influential. I recognize that with that influence comes a concomitant responsibility to assure that the analyses meet the highest standards of integrity and professional competence. I intend to see that they do, that they are done in an open and explicit way, that they are documented and reproducible, and that they are made available to the Services for their inspection and rebuttal. I feel that such procedures, long considered routine in scientific research, are the best way of assuring a quality of analysis equal to the importance of the decisions it will influence. [Ref. 80: pp. 11-12]

After they analyzed the 8-18 Study, Mr. Murray and his staff took issue with almost every point made in the study. The PA&E staff were as firm in their choice of the F/A-18 as the Marines were in their choice of the AV-8B. The OSD analysts liked the larger, twin-engined, supersonic F/A-18 better because of its dual nature, it can be both a light attack bomber and an all-weather fighter. Mr. Murray said in 1981 that the 8-18 Study served as the principal source for the quantitative side of the AV-8B controversy, and that "...little more of any fundamental significance has surfaced in the intervening three years." [Ref. 81: p. 50] The PA&E analysis of the 8-18 Study concluded that the original Navy/Marine Corps analysis was not done correctly. Points of the study disputed by PA&E fell into three main categories [Ref 81: pp. 52-53]:

1. Costs:

PA&E maintained that the 8-18 analysis charged the A-18 option with the costs of seventy-two A-4 Skyhawks

to be bought to fill a short term shortage, but that the shortage was left unfilled in the AV-8B alternative. PA&E said that the AV-8B's could not be built fast enough to fill the shortage, so they deleted the A-4 costs from the A-18 option. PA&E applied discounting to the costs of the two options. The AV-8B option had more research and development costs yet to come in its program, while the A-18 program had already completed its R&D phase. Because the R&D costs still associated with the AV-8B program caused it to be "front-loaded," the application of discounting lowered the cost of the A-18 relative to the AV-8B. The combination of the A-4 adjustment and the application of discounting altered the relative costs of the two aircraft so that under the PA&E analysis the cost ratio was 4 F/A-18's for the price of 3 AV-8B's.

2. Close Air Support:

- a) PA&E maintained that there is no generally accepted estimate of how quickness relates to goodness in the responsiveness of close air support. They maintained that the values for responsiveness used by the Marines in the study, which were based on combat experience, may not have been valid because it's difficult for an analyst to distinguish between (a) valid and accurately perceived combat experience, (b) what the combat veteran honestly, but mistakenly thought was going on in the heat of battle, and (c) what merely masquerades under the authoritative guise of combat experience. The PA&E answer to this problem was to conduct a "sensitivity analysis" on the responsiveness portion of the A-18's effectiveness analysis. PA&E found that when they arbitrarily doubled the the times allowed for

the aircraft to get to the targets, there was no advantage for the AV-8B. That was not surprising because getting to the target quickly is what the AV-8B does best. PA&E also found that cutting the time allowed for the aircraft to get to the target had the same result of eliminating any advantage for the AV-8B. They deduced from this that the particular parameters used in the study were chosen by the Marines to maximize the advantage of the AV-8B over the A-18.

- b) PA&E also took exception to the way that the A-18's were forced to operate in the study scenarios. In the study the A-18's were called from ground alert at a base that was 100-150 miles to the rear of the FEBA, instead, the A-18's should have been placed in combat air patrol (CAP) stations in the vicinity of the battle ("air loiter"). The CAPPING of the A-18's improved their score significantly, by about 25% for a base 100 miles away and about 40% for a base 150 miles away. PA&E also thought that it was unrealistic to make the A-18's retire to a CAP station 20 miles away from the target area before returning to make a second pass at any target.
- c) PA&E also took exception to the study's assumption that the A-18's would be based 100-150 miles from the FEBA, and determined that the average distance from any random spct to a base with a runway long enough for the A-18 was less than 50 miles in Europe, the Middle East, or in Korea.

3. Airbase Vulnerability:

PA&E argued against the AV-8B's basing flexibility advantage over the A-18 on two counts. First, the 8-18 Study did not account for any difference in the likely

losses of enemy aircraft in attacking the bases in the study. For the AV-8B the enemy would only have to penetrate less than 20 miles of defenses for some forward sites and perhaps 50 miles for main bases, but for the A-18 bases the enemy would have to penetrate 100-150 miles. Second, if the runways of our airbases could be cut, then the rest of the Marine fixed wing aircraft: the fighters, the medium attack, the tankers, and the electronic countermeasure aircraft would be grounded. If the enemy has enough air power to cut our runways, and we can't get any fighters into the air, then the enemy has air superiority. Because of this, PA&E maintained that in a situation of enemy air superiority, even if they could get into the air, the AV-8B's would not survive long enough to make any difference.

C. THE MARINE CORPS' ANSWER TO OSD CRITICISM

The Marine Corps, of course, did not agree with the PA&E analysis of the 8-18 Study. LtGen Miller expressed how the Marines looked upon the developing controversy when the results of the study and the V/STOL concept developed by the Marine Corps was challenged:

We have a lot of experts around town who haven't seen a shot fired in anger in war who seem to think they know more about what we need to fight a war with than those of us who have spent thirty-five to forty years fighting it. That's the part that's a little frustrating. The Marine Corps has always been value-conscious of the assets provided it, but we also never cease attempting to improve our capability to do our job better and more efficiently. Therefore, cutting out the AV-8B from the 1980 Defense Budget will just delay it for as many years as those people who apparently believe they have greater wisdom than we, prevent us from continuing to obtain the best weapons systems possible. [Ref. 34: p.53]

The Marine Corps in turn answered with its own critique of the OSD analysis of the 8-18 Study.

1. Costs:

The Marine Corps cited several cost analyses done since the 1977 8-18 Study that showed [Ref. 11: p. 59]:

- a) If AV-8B procurement were added to the programmed F/A-18 procurement, more rather than less aircraft could be acquired for the same overall cost. To do this there would have to be a trade-off of expensive outyear (inflated) F/A-18 procurement for greater near year costs.
- b) If the life cycle costs are considered, as they were in the 8-18 study, then approximately three percent more aircraft could be procured in the AV-8B mix.

2. Close Air Support: [Ref. 11: p. 60]

- a) To the charge that it had chosen the responsiveness parameters in the 8-18 Study to maximize the advantages of the AV-8B, the Marine Corps answered that to the contrary, the AV-8B employment concept had been developed to meet the required responsiveness. The target urgency and value decay times used in the 8-18 study were supported by the Joint Chiefs of Staff [Ref. 58: p.43]. They also claimed that the times used by PA&E in their "sensitivity analysis" (half of the stipulated times in the study) were times that could not be practically attained by any aircraft.
- b) The PA&E analysis also assumes perfect mission convertability between fighter and attack for the F/A-18. The A-18 only realizes its full benefit in the post-attack retirement. The Air Force learned in Vietnam that mission convertability does not work. [Ref. 58: p. 43]

- c) The Marine Corps agreed that "air loiter" for the A-18 would maximize responsiveness, but the Combat Air Patrol technique of handling on-call close air support missions had been proven in the past to be inefficient and unsupportable over the long term. It is efficient only for short periods of intense combat, whereas the forward basing concept of the Harrier is efficient in all cases and maximizes sortie rate while minimizing fuel usage.
- d) To the requirement of making the A-18 retire 20 miles (a distance that equates to 2.5 minutes flying time) before making a second pass at the target, the Marines answered that in the 8-18 Study that requirement was imposed on the AV-8B as well and is a necessary tactic for survival on a modern battlefield saturated with surface to air weapons along the FEBA.
- e) The Marine Corps assumption of the conventional airbase being a distance of 100-150 miles behind the FEBA is again based on combat experience and official scenarios which show that conventional aircraft will be based up to as much as 200 miles from the battle area.

D. OSD SPLITS ON THE AV-8B

After seeing the analysis from his own PA&E office, Secretary Brown's mind was firmly made up against the AV-8B. Even after the Congress had restored the funds he had taken out of the budget in 1979, Mr. Brown remained adamant about the Marine Corps not getting the AV-8B. During the budget process for FY1980, the Navy included the AV-8B in the Program Objective Memorandum (POM) with its other top priority items that would make up the budget at a minimum funding

level. However, OSD directed that the program be moved from the minimum to the basic level during the program review. This means it was given a lower priority. That movement was objected to by the Navy in a "reclama," but OSD stood by their action. Next, the Navy moved the AV-8B program to what was called Band One, the highest priority level the program could be given outside the minimum budget. During the later stages of the budget process OSD moved the program again, this time to Band Three. The decision on where to place the AV-8B program was made at the highest levels within the OSD. [Ref. 46: p. 576] In 1979 Secretary Brown testified to Congress:

My cancellation of the AV-8B program shows how I feel about that program. The AV-8B is basically an updated AV-8A designed to correct many of the deficiencies seen in the earlier aircraft. The AV-8B does not represent an advance in the state-of-the-art in V/STOL technology, nor does it provide the capability that the Navy desires for sea-based operations. [Ref. 61: p. 76]

For the second year in a row, Congress restored the AV-8B funding to the budget.

The following year, the very same actions were taken by the Marine Corps, the Navy, OSD, and Congress. The AV-8B was included in the basic level of the Department of the Navy budget when the budget was initially put together. When the AV-8B was moved to a lower priority by OSD, the Marine Corps recommended that it be put back. The Marines recommended that the A-18's budgeted for the Marine light attack force be taken out as an offset for restoring the AV-8B's to the highest priority. OSD did not do this. After the budget process was complete, the AV-8B program again did not appear in the budget at all. [Ref. 48: p. 854] While testifying on the FY1981 budget in 1980, Mr. Brown again let Congress know exactly where he stood on the AV-8B program:

Mr. Edwards. How are you and the AV-8B doing?

Secretary Brown. Well, as you know, it is not in the budget, and the reasons are the same as they

were last year. They include high cost and relatively small numbers for a special capability that is highly advantageous in one way, namely, short field or vertical takeoff, but really quite limited capability when compared, for example, to the F/A-18's which is the alternative for the Marine Corps.

What I am afraid of Mr. Edwards, is that the Congress will year by year force us to do the R&D and then when it sees the procurement cost per item, will change its mind and agree that the procurement is not in order and say why did you waste all this money. [Ref. 82: pp. 523-524]

While Secretary of Defense Brown and his Assistant Secretary for PA&E were thoroughly against the AV-8B, there were other important officials in the Department of Defense that were in favor of the AV-8B. At the time of DSARC I for the AV-8B, in early 1976, the Director, Defense Research and Engineering (DDR&E) stated that the Marine Corps requirement for an all V/STOL light attack force should remain an open issue until DSARC II, about the middle of 1979. A key point stressed by DDR&E was the operational utility of the Harrier in the NATO environment due to its basing flexibility [Ref. 42: p. 20]. An earlier director had been opposed to the Marines original acquisition of Harriers from Britain, but after observing the Marines basing concept for V/STOL during Exercise VERSATILE WARRIOR he was completely won over and fully endorsed the Harrier for the Marine Corps [Ref. 17: p. 52].

In early 1980, the Defense Science Board came out strongly in favor of the AV-8B after a study done by its Task Force on V/STOL Aircraft [Ref. 62: p. 56]. One member of that task force made the following statement concerning the importance of V/STOL:

...history provided ample evidence of the folly of mortgaging the future to pay for the present. If steps are not taken now to insure the continuity and expansion of V/STOL operational experience, there is little chance that V/STOL, STOVL or any other alphabetic arrangement signifying the use of power to augment conventional takeoff and landing characteristics will be available when required. [Ref. 12: p. 30]

The Defense Science Board's task force was definitely in favor of V/STOL. They recommended that the AV-8B proceed through complete evaluation of STOL and STOVL operations. It was clear that the AV-8B was the only aircraft around that was going to be able to give the U.S. any operational experience in order to move V/STOL into the future. The Board also praised the AV-8B as a worthwhile replacement for the "very limited" British AV-8A. [Ref. 62: p. 56]

Other officials within the Office of the Secretary of Defense who were in favor of the AV-8B were: Under Secretary of Defense for Policy Robert Komer, Under Secretary of Defense for Research and Development Dr. William Perry, and Deputy Secretary of Defense W. Graham Clayton, Jr. [Ref. 83: pp. 41-42]. Mr. Clayton had become an advocate of V/STOL and the AV-8B while he was the Secretary of the Navy [Ref. 42: p. 19].

E. OSD VERSUS CONGRESS

Secretary of Defense Brown tried to fight Congress on their continuation of the AV-8B program. After Congress restored the fiscal year 1979 funds for the Advanced Harrier program that Brown had cut from the President's budget, the Department of Defense tried to hold back those funds. Congress had approved \$123 million in fiscal year 1979 funds for research, development, testing, and evaluation of the two YAV-8B's. [Ref. 41: p. 49] In January 1979 the Department of Defense deferred about \$108 million of those funds, letting the Marine Corps spend the remaining \$15 million for the YAV-8B Prototype program [Ref. 47: p. 545]. Some members of Congress, especially the supporters of the AV-8B program, were upset about what DOD was doing with money that they had appropriated for an authorized program. While the committees were conducting their hearings on the

fiscal year 1980 budget, they questioned their witnesses about DOD's holding back of the 1979 AV-8B funds.

Secretary Brown himself was asked about this matter by the Senate Subcommittee on Defense Appropriations:

Senator Young. Is it true that FY1979 funds which Congress mandated in last year's budget for the AV-8B have been deferred?

Secretary Brown. The President's budget for FY80 includes no funds for the continuation of the AV-8B program in FY80. Under Secretary Perry authorized the Navy to complete the FY79 Advanced Development program with no funding or programmatic changes. He also authorized the Navy to spend up to \$15M of their FY1979 Engineering Development funds to sustain current personnel levels and conduct limited development activities both in the US and UK. We do not intend to put the AV-8B into Full Scale Development. Present plans should permit reasonable exploitation of the flight test aircraft prior to program termination.

Senator Young. Is the continuation of deferral of the FY79 funds and the FY1980 budget intended to kill the AV-8B? If so, why was this action taken without notifying Congress of the deferral of funds in accordance with the Anti-Impoundment Control Act?

Secretary Brown. We have decided to terminate the AV-8B program, for reasons we previously stated. At the present time the program is continuing but will be closed out later this year. As we will be spending about \$60M of the Advanced and Engineering funds appropriated for FY79, we believe that no additional notification is necessary at this time. [Ref. 84: p. 465]

General Wilson was questioned:

Senator Stennis. The \$108 million deferral, as I understand, would cause a slippage in the program. You are referring to money that has already been appropriated for fiscal 1979. Is that correct?

General Wilson. Yes, sir, of the \$123 million that was appropriated and authorized in 1979, \$108 million has been deferred.

Senator Stennis. I call that to the attention of the subcommittee. This subcommittee's duty is to try and help set priorities.

What was the sum of money for the AV-8B that got left out of the fiscal 1980 budget request sent to Congress?

General Wilson. That was \$203 million in fiscal year 1980.

Senator Stennis. \$203 million?

General Wilson. Yes, sir.

Senator Stennis. Of course, nothing has happened since then to lessen the need for this program?

General Wilson. That is true. I might say that, if the Congress should see fit to appropriate money for fiscal year 1980, the deferral of fiscal year 1979 funding is costing us roughly \$7.5 million for each month of delay.

Senator Stennis. We appreciate that information. It will be our duty to pass on the program one way or the other.

Senator Young. First, General Wilson, what reason was given for the deferral of the \$108 million?

General Wilson. The reason was given that the R&D funds were deleted from the 1980 budget. Therefore, this would presumably be a wind-down of the AV-8B program. Accordingly, it was presumed that since it was not requested by the President, the money would not be approved by the Congress.

Now, there are two YAV-8B's that have been built. One is now flying at Patuxent River, and one is flying at the McDonnell Douglas factory in St. Louis.

Senator Bumpers. How many of those are there?

General Wilson. Two, sir.

Senator Young. In other words, the program is being terminated?

General Wilson. For all practical purposes, yes. \$15 million will be the wind-down.

Secretary Claytor. \$15 million, keeping the present test going and that is all.

General Wilson. Yes.

Senator Young. Will that seriously hurt the business?

General Wilson. I believe it will, sir.
[Ref. 45: pp. 939-940]

General Wilson had raised the point that if the program were to be continued over the objections of OSD, then the deferral of the development funds in early 1979 was adding a great deal of cost to the program. This point was emphasized by other Navy Department officials during testimony in other hearings before Congress [Ref. 47: pp. 1043-1045 and 85: pp. 386-387].

Senator Hart. General Miller, what is the status of the fiscal year 1979 funds which Congress authorized and appropriated for AV-8B engineering development? Is there any impact on schedule?

General Miller. Of the \$123 million funds authorized for the AV-8B Program in fiscal year 1979, \$108 million have been "deferred" or not released. The continued inability to commit these funds could incur a delay in Initial Operational Capability (IOC)* and will certainly increase downstream costs. [Ref. 47: p. 1050]

As a result of the deferral, congressional advocates of the AV-8B of the AV-8B put pressure on Secretary Brown to release the \$108 million to the Marine Corps. Because Congress perceived the holding back of the AV-8B funds as unauthorized deferral of Congressionally authorized funding, the pro-AV-8B sentiment built up in a backlash against OSD. It was expected that Senator Gary Hart was going to take some action to force the spending of the \$108 million, but before he had to take any action, the Defense Department agreed to release the money. House and Senate aides predicted that legislators would continue to "express their will" in favor of the AV-8B over the objections of the Office of the Secretary of Defense. [Ref. 60: p. 16]

The delays that the OSD made in the AV-8B program caused a substantial cost growth in the program. At the beginning of 1980, the cost growth in the program was estimated at nearly \$1 billion. Most of that cost growth was attributable to the OSD delays. In a report to Congress, the Comptroller General of the United States stated:

Two Department of Defense funding actions resulted in delaying the AV-8B procurement program. The combined effect of these actions postponed the AV-8B's initial operational capability by 2 years and was the principal cause of the program's cost growth. The AV-8B's initial operational capability is now planned to occur in 1986. Each year that the initial operational capability milestone was delayed, total acquisition costs increased an average of \$461 million. [Ref. 86: pp. 5-6]

The two delays referred to in the Comptroller General's report were the withholding of the \$108 million in FY1979 funds and the absence of any request for AV-8B funds in the FY1980

* The IOC occurs on the date that the 30th aircraft is delivered to the Marine Corps [Ref. 86: p. 6].

budget, which caused a new five year profile to be drawn up after Congress reinstated AV-8B funding for that year also [Ref. 86: p. 6].

VI. SUMMARY AND CONCLUSIONS

A. SUMMARY

Throughout the 1970's, the U.S. Marine Corps conducted a Vertical and Short Take-Off and Landing (V/STOL) aircraft experiment with the AV-8A Harrier. The Harrier, an airplane of British manufacture, was originally developed to satisfy a requirement laid down by Britain's Royal Air Force (RAF) for a small, lightweight reconnaissance/fighter/attack aircraft that could operate independent of the easily targetable runways of Europe, and operate from dispersed sites close to the forward edge of the battle area (FEBA). To fill that RAF requirement, the Hawker Siddeley Aircraft Company, which later became part of British Aerospace, developed and produced the Harrier. The Harrier, designated the AV-8A by the United States, is a single seat, single engined, V/STOL airplane. The Harrier operates on the vectored thrust principle, utilizing four rotatable exhaust pipes, or nozzles, which are placed in pairs on either side of the airplane. The four nozzles are placed symmetrically about the plane's center of gravity. The nozzles are rotated down for vertical flight and to the rear for forward flight. After the RAF ordered their first Harriers in 1967, the U.S. Marine Corps began to look seriously at the Harrier to fill their long-standing requirement for a fixed-wing V/STOL jet aircraft that could operate from helicopter-sized platforms on ships, as well as from small clearings near the FEBA. With the Harrier, the Marines could increase the responsiveness of the direct air support received by ground combat units. The Harrier would also enable the Marines to establish their light attack force in operations ashore such

sooner than conventional airplanes during an amphibious assault. The first of three combat light attack squadrons to be equipped with AV-8A's became operational in 1971.

Very soon after beginning to operate their Harrier squadrons, the Marine Corps established a requirement for a follow-on V/STOL to become operational in the 1980's. This descendent of the AV-8A was to be improved enough in range and payload to replace all the airplanes in the Marine light attack force, both AV-8A's and A-4 Skyhawks. This second generation Harrier, the AV-8B, was to be built by McDonnell Douglas, an American company, in cooperation with British Aerospace, Rolls Royce of England, and another American company, Pratt & Whitney. In their AV-8B design, McDonnell Douglas used the same engine as the AV-8A and made use of lightweight graphite epoxy composite materials in the place of much of the metal structure, an aerodynamically improved wing, lift improvement devices, and state-of-the-art electronics to give the AV-8B twice the performance of the AV-8A. With an all AV-8B light attack force, the Marines would be one step closer to their long range goal of converting their air wings entirely to V/STOL aircraft. However, getting the AV-8B was not easy.

When Harold Brown became Secretary of Defense under President Jimmy Carter, he tried to discontinue the AV-8B program, which had been supported by previous Secretaries of Defense. Secretary Brown was convinced by Russell Murray II, his Assistant Secretary of Defense for Program Analysis & Evaluation (PA&E), that the McDonnell Douglas F/A-18 Hornet fighter/attack aircraft was less expensive and superior to the Advanced Harrier. The Marine Corps did want the F-18 as a fighter to replace their worn out F-4 Phantom fighters, but they did not want to give up the V/STOL capability of the AV-8B in their light attack force for the A-18 attack version of the Hornet.

A Navy-Marine analysis showed that the AV-8B was not only more effective in the close air support role than the A-18, but that a mixed F-18 and AV-8B force was no more costly over the life of the aircraft than the all F/A-18 force favored by Secretary Brown and Mr. Murray. After the Navy-Marine analysis was published Mr. Murray convinced Dr. Brown that the study was not valid and that a common F/A-18 aircraft for the Navy and the Marines was the best choice. During the FY79 budget debate, Acting Secretary of the Navy R. James Woolsey summarized the Navy-Marine view of the AV-8B for the Secretary of Defense:

In summary, we think we have a fine airplane that will pave the way for many potential revolutions in aviation. Those who asserted so confidently that the range and payload limitations of the AV-8 were immutable have now grown a bit quieter on this issue, given the performance of the AV-8B's supercritical wing and the continuing and exciting British work with the ski jump. CINCEUR has recognized the airfield vulnerability problem for which V/STOL is a recognized solution. This problem is certain to grow worse in years to come with the advent of cruise missiles and cluster munitions, especially in short conflict situations (or in the opening phases of a long one). We are in our infancy in assessing the payoff of V/STOL for naval forces. The Marines know of the AV-8's benefits in close support, particularly in the early stages of hostilities. It is a landmark joint weapon development program with the UK, holding such promise for our NATO interoperability objectives.

In the 1940s we had some difficult years developing helicopters. A lot of people weren't sure exactly what missions they would be used for. No one then could have done, or did, a detailed cost effectiveness analysis of their utility for such missions as firing wire-guided missiles against tanks, interrogating sonobuoys with sophisticated signal processing gear, or lifting sixteen tons. Yet we now routinely use helicopters for these major tasks. Happily, we did not think ourselves smart enough then to stop work on a new way to fly because we could not see the future clearly. I don't know all of the advantages that the AV-8B will bring to U.S. aviation. Nor does anyone. But I don't think we can afford to terminate our only V/STOL aircraft today... [Ref. 87, pp. 7-8]

Each year that he was the Secretary of Defense, Dr. Brown, on the recommendation of his assistant, Russell Murray, cut from the defense budget the AV-8B funding

requested by the Marine Corps. Each year that happened, the Secretary of the Navy, the Chief of Naval Operations, the Commandant of the Marine Corps, and the Deputy Chief of Staff Marine Corps for Aviation, as well as some other officials, testified before the House and Senate Armed Services Committees and the House and Senate Appropriations Committees that the Marine V/STOL concept was valid and operationally proven and that the Marine Corps needed the AV-8B. Secretary Brown testified before the very same committees that the Office of the Secretary of Defense analysis showed the AV-8B to be inferior to and more expensive than the F/A-18. Each year the Congress restored the research & development and procurement funds necessary for the Marines to begin to operate AV-8B's in 1985.

After Ronald Reagan became president, and Harold Brown was no longer the Secretary of Defense, the Marines considered the battle of the AV-8B won at last, that they had overcome DOD opposition and the sometimes less than all-out support of the U.S. Navy. The Reagan administration requested funds in the FY82 budget for the first production models of the AV-8B [Ref. 88: p. 15]. Lieutenant General William J. White, the present Marine Corps Deputy Chief of Staff for Aviation said:

After a long and difficult struggle, the AV-8B is finally an established program... With the present rate of progress, I see no real difficulty in meeting the goal of having AV-8B's operational in 1985 and then moving ahead to complete the transition of all eight light attack squadrons by 1989. [Ref. 32: p. 42]

B. CONCLUSIONS

In 1969 Graham T. Allison, a professor of politics at Harvard, published an article in which he proposed:

1. Most analysts of choices and actions of national governments explain the behavior of those governments in

terms of a basic conceptual model called the Rational Policy Model.

2. There are two alternative conceptual models that could provide a base for improved explanation. These other two models are called the Organizational Process Model and the Bureaucratic Politics Model.

Allison explains his models principally in terms of happenings in foreign policy decision making, his approach was developed from a study of the Cuban Missile Crisis, but the models can be generalized for government decisions about the military, including weapons procurement decisions.

[Ref. 89: pp. 689-718]

The Rational Policy Model as explained by Allison says that Government actions maximize strategic goals and objectives. The government is seen as a rational, unitary decision maker. This single actor (the government) has one set of specified goals, one set of perceived options, and a single estimate of the consequences that follow from each alternative. In this model, the action selected by the government is the alternative that is value maximizing, i.e. the alternative whose consequences rank highest in terms of its goals and objectives. An analyst using this model would infer from a particular action that the government taking the action must have had ends toward which the action constituted an optimal means. The central idea of value-maximizing implies the following:

1. An increase in the cost of an alternative, or a reduction in the value of the set of consequences, or a reduction in the probability of attaining a fixed set of consequences, reduces the likelihood of that alternative being chosen.
2. A decrease in the cost of an alternative, or an increase in the value of the set of consequences, or an

increase in the probability of attaining a fixed set of consequences, increases the likelihood of that alternative being chosen.

Allison's Bureaucratic Politics Model says that many actors who are positioned hierarchically within the government, and who individually focus on diverse issues, decide what actions the government will take based on bargaining along regularized channels, such as PPBS and the budget process. The power in government is shared by these somewhat independent political leaders who have ascended to the top of the bureaucratic apparatus. Because men share power and they differ on what must be done, policy is resolved by politics. Often, the pulling on a decision in different directions by different groups results in an action that is distinct from what anyone intended. In this model the government action is not a chosen solution to a problem, but an outcome resulting from compromise, coalition, competition, and confusion among government officials who see different faces of an issue. The model is political in the sense that the final action is a result of bargaining.

How was the government's action on the decision to buy the AV-8B determined? Was the final outcome the result of choosing among alternatives that had the highest valued consequences, the most probability of success, or the least cost? Or, was the outcome the result of compromise, coalition, and competition? The case study assembled in the preceding four chapters of this thesis seems to clearly fit the third Allisonian Model - Bureaucratic Politics.

"Rational" analyses done by both sides in the AV-8B controversy determined sets of costs, probabilities of success, and values of alternatives completely in opposition to each other. The way those analyses actually figured into the final action was such that the hierarchial bureaucratic power

on each side did not have much effect. The Office of the Secretary of Defense, from a position of great power in the executive branch, made a decision that its analysis was best. This in turn led to the decision to cancel the AV-8B program. The Marines, from a position several rungs lower on the bureaucratic power ladder, showed that it was political power that made the difference in the AV-8B decision. The Marines took their analysis, along with their close air support expertise, their reputation, their V/STOL experience, and their charisma (General Wilson was a recipient of the Congressional Medal of Honor and recieved a standing ovation from the Congressmen and Senators each time he testified) to Congress and successfully outplayed their DOD opposition in the political game.

Which side was right? That question will not be answered until the Marines take their Harriers to war. But, there may be an indication of the Harrier's usefulness in the early results of Britain's conflict with Argentina in the South Atlantic. Because Britain has no large aircraft carriers, the Harrier was the only fixed wing aircraft that could be taken to the Falkland Islands on the two small aircraft carriers available. HMS Invincible and HMS Hermes each carried twice the normal complement of Royal Navy Sea Harriers to the Falklands, for a total of twenty Harriers [Ref. 90: p. 26]. The second task force sent by the British prior to their invasion carried eighteen more Harriers. The second group of Harriers was made up of model Gr.3's, Royal Air Force versions equivalent to the AV-8A. The British did not have another aircraft carrier to send South, so the second group of Harriers was transported on an 18,000 ton container ship, the Atlantic Conveyor [Ref. 91: p. 27]. The concept of operating Harriers from modified merchant ships, discussed in Chapter II, was studied by Colonel James W. Orr,

USMC [Ref. 16], and dramatically demonstrated by the British. The use of that concept highlighted the importance of the Harrier's flexibility. Once in the South Atlantic, it was predicted by some that the Harriers would be outgunned by the 230 plane force of Argentina's Air Force and Navy. Among Argentina's planes were twenty-one Mirage III's (a French supersonic fighter), twenty-six Daggers (Israeli modified Mirages), and eighty-two A-4 Skyhawks (the McDonnell Douglas light attack plane) [Ref. 91: p. 28]. According to the British Defense Ministry, as of the first week of June 1982, Harriers had been responsible for downing at least twenty-five of the sixty-nine Argentine planes and helicopters destroyed. While the British downed sixty-nine planes, they lost only six Harriers, and none of those were shot down by enemy planes. The advantage the Harrier has over the Mirages and A-4's is its superior maneuverability. The British pilots are taking full advantage of the VIFFing technique (Vectoring In Forward Flight) developed by U.S. Marine pilots. VIFFing allows the British pilots to decelerate so suddenly, that the enemy planes overshoot the Harriers and then the quick acceleration of the Harrier, with its high thrust-to-weight ratio, lets it become the pursuer instead of the pursued. [Ref. 92: p. 16A and 93: p. 38]

The British accomplishments in the Falklands were in a conflict that is on a smaller scale than is envisioned in many of the scenarios found in Marine contingency plans. The British were successful with older Harrier models that perform only half as well as the AV-8B. The Harrier has been successful in the South Atlantic so far, and may prove that the right decision was made in acquiring the AV-8B.

APPENDIX A

CHRONOLOGY OF HARRIER DEVELOPMENT

1958

Hawker Siddeley designs a V/STOL around the Bristol BE5 vectored thrust engine

1959

BE5 engine funded by the MWDP (75%)

1960

P.1127 prototype makes first tethered flight

P.1127 prototype makes first free flight

1961

P.1127 makes first full transition from a hovering takeoff to straight and level flight

1965

Tripartite squadron formed around nine Kestrels

Hawker Siddeley gets a development contract for the Harrier from the British Government

1966

First Harrier model is introduced

1967

First production Harrier completed

Royal Air Force orders 90 Harriers

1969

U.S. Marine Corps orders 12 Harriers (AV-8A's)

First RAF Harrier squadron is operational

1971

VHFA-513 receives first 6 AV-8A's and is redesignated as VMA-513

Marines plan purchase of 84 more AV-8A's

1972

McDonnell Douglas and Hawker Siddeley work on a second generation Harrier, the AV-16A

Exercise VERSATILE WARRIOR validates Marine V/STOL doctrine and concept

1973

Marine Corps submits SOR for an advanced V/STOL to replace A-4's and AV-8A's

Marine Corps makes final order for AV-8A's for a total of 110 (including 8 YAV-8A two-seat trainers)

1974

United Kingdom rejects cost-sharing plan for AV-16A
AV-16A plans are cancelled

1975

Marine Corps now has 4 AV-8A squadrons (one training)
McDonnell Douglas announces plans for its own AV-8B

1976

DSARC I approves AV-8B plans, recommends prototypes be developed by rebuilding two AV-8A's

OSD authorizes two YAV-8B's

1978

YAV-8B prototype testing begins

1981

MOU between U.S. and U.K. for joint production of AV-8B's for the Marine Corps and the RAF by McDonnell Douglas with British Aerospace and Rolls Royce with Pratt & Whitney

First of four full-scale development AV-8B's begins testing

1985?

First Marine AV-8B squadron is operational

APPENDIX B **AIRCRAFT SPECIFICATIONS**

AIRCRAFT CHARACTERISTIC → ↓	AV-8B	F/A-18	AV-8A	YAK-36	A-4M
WING SPAN (FT)	30	38	25	25	28
LENGTH (FT)	46	56	46	53	46
HEIGHT (FT)	12	15	11	13	15
EMPTY WEIGHT (LBS)	12,500	21,500	12,400	15,430	10,800
MAXIMUM TAKEOFF WEIGHT (LBS)	19,650 VTO 28,750 STO	33,585 F 47,000 A	17,050 VTO 22,300 STO	22,000 VTO	24,500
MAXIMUM SPEED (MPH)	720	1,300	660	770	850
SERVICE CEILING (FT)	50,000	50,000	50,000	40,000	49,000
FERRY RANGE UNREFUELED (MILES)	3,000	2,3000	1,170	---	2,050
INTERNAL FUEL (LBS)	7,500	10,860	5,160	5,400	5,400
EXTERNAL FUEL (LBS)	8,330	5,140	3,920	1,360	6,800
NUMBER OF ENGINES	1	2	1	3 1 PRIMARY 2 LIFT	1
THRUST	21,700	16,000 EACH	21,500	17,500 PRI 7,950 EACH LIFT	11,200
MANUFACTURER	MCDONNELL DOUGLAS	MCDONNELL DOUGLAS	BRITISH AEROSPACE	YAKOVLEV USSR	MCDONNELL DOUGLAS

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